

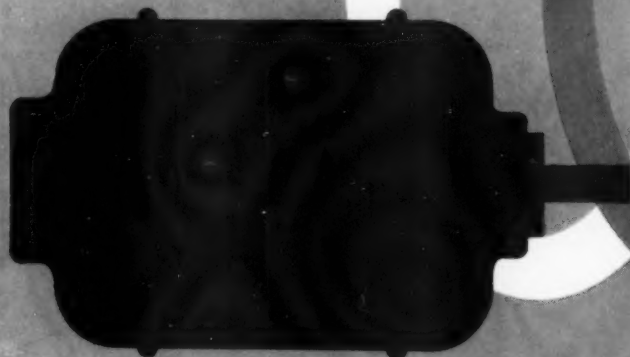
# POWER TRANSMISSION DESIGN

NOVEMBER 1960

MACHINE DRIVES & COMPONENTS

STEVENS RICE  
UNIVERSITY MICROFILMS  
313 N FIRST ST  
ANN ARBOR MICH 48106-1501

## SELECTING AC MOTORS



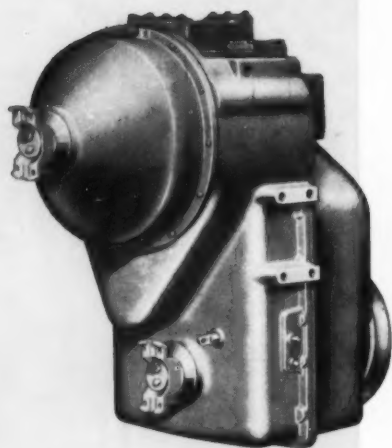
ALSO IN THIS ISSUE:

- Unlubricated Plastic Bearings
- New Ball-Galaxy Transmission



INCLUDING BEARINGS DESIGN / APPLICATION

Read by 40,000 men who specify power transmission products  
for original equipment and in-plant applications



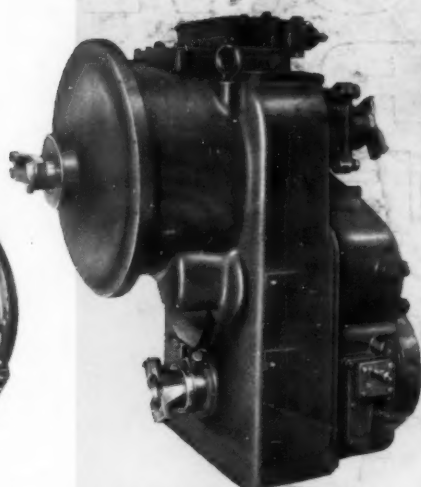
**HYDRA-DRIVES  
BDB  
Transmission**

- Four speeds forward and reverse.
- Full power shifting.
- For equipment up to 175 h.p.



**HYDRA-DRIVES  
Torque Converter**

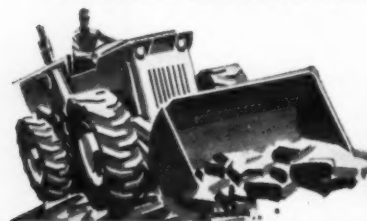
- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
- For vehicles up to 500 h.p.



**HYDRA-DRIVES  
CDB  
Transmission**

- Four speeds forward and reverse.
- Power shift in each range both forward and reverse.
- For equipment up to 250 h.p.

**PEAK POWER OUTPUT FOR HEAVY-DUTY EQUIPMENT...**



# **Hydra-Drives®**

## **Power Shift Transmissions and Torque Converters**

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless — even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts without interruption of the power flow.

Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.

*Another Product of...*

**ROCKWELL-STANDARD**  
CORPORATION



Transmission and Axle Division, Detroit 32, Michigan

Circle No. 52 on Reader Service Card

# maurey

## positive drives

give you three mighty advantages

### 1 SMOOTH, SLIP-PROOF POWER TRANSMISSION

With belt teeth meshed in pulley grooves, Maurey Positive Drives are slip-proof as chain and gear drives. Maximum power moves to work smoothly, quietly, with uniform speed. There is no rise and fall of pitch line, no slippage, no creeping, no backlash. Here, in brief, is smooth, positive power transmission on heavy loads or the finest precision work.

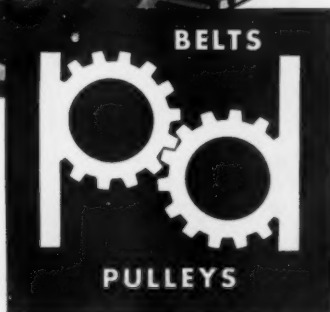
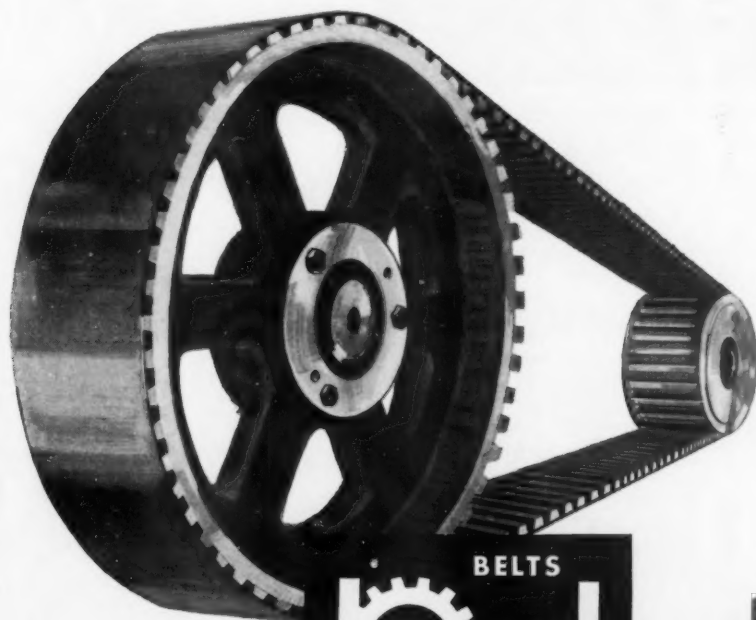
### 2 WIDE RANGE OF SPEED AND HORSEPOWER IN COMPACT SIZE

From fractional horsepower to 600 h.p., Maurey Positive Drives are proven drives. Their normal belt speeds range from 100 fpm to 10,000

fpm. Belts and pulleys combine maximum horsepower with minimum space. This inherent compactness is a vital advantage to the designer facing weight and space limitations.

### 3 LOW COST POWER TRANSMISSION

Since the Maurey Positive Drive does not rely on friction, high initial belt tension is not needed. That means minimum bearing load all the time, and low heat build-up while the drive runs. With no metal-to-metal contact, there is no need of lubricating systems. Adjustable motor bases and idlers are frequently eliminated. With no "extras" and practically no maintenance, here is true economy.

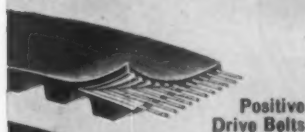


See your Maurey Distributor for help in selecting the right positive drive for your requirements. Write for catalog information.

NOVEMBER, 1960

Circle No. 43 on Reader Service Card

get more **drive**  
with Maurey drives



WRITE FOR CATALOGS

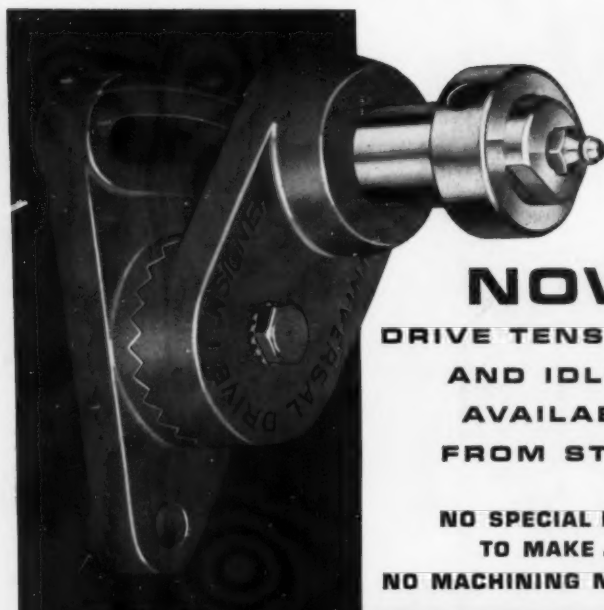
# maurey

MANUFACTURING CORPORATION

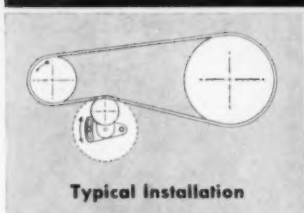
2907-23 So. Wabash Ave., Chicago 16, Ill.  
Phone: Danube 6-5151

First Service from these Maurey Warehouses

CLEVELAND: 3200 Lakeside Avenue • Phone: MAin 1-2242  
KANSAS CITY, Mo.: 1728 Walnut • Phone: BAltimore 1-3330



Base Mounted  
Model 25: \$15.00  
Patent pending



Typical Installation

**NOW**  
**DRIVE TENSIONERS**  
**AND IDLERS**  
**AVAILABLE**  
**FROM STOCK**

**NO SPECIAL PARTS**  
**TO MAKE...**  
**NO MACHINING NECESSARY**



Bronzed Bushed Idlers  
14 Standard sizes

Shaft Mounted  
Model 2A: \$12.00

## UNIVERSAL DRIVE TENSIONERS PROVIDE A SIMPLE, PRACTICAL LOW COST WAY TO TAKE UP SLACK IN CHAIN AND BELT DRIVES

Here is the most economical and efficient way to: (1) Reduce horsepower losses through belt slippage, (2) Eliminate shock loading on chain drives and (3) Increase the life of your equipment.

**Easy To Adjust For Proper Tensioning.** Exact tensioning is assured by tensioner arm which can be rotated and locked in any position on a 360° arc. An exclusive Universal Drive Tensioner feature.

**Tensioners:** The *Base-Mounted Tensioner* is adaptable to virtually all machine frames, while the *Shaft-Mounted* type is easily locked at any point on a shaft. A 2 inch long interchangeable shaft is supplied with each tensioner and 3 or 4 inch long

shafts are available for multiple width drives.

**Bronzed Bushed Idlers:** All idlers have 1 inch standard bores. *Sprockets* are made in all standard sizes from No. 35 through No. 80 roller chains in both single and double widths. *Pulleys* are made in 1, 2 and 3 inch face widths with a 4 inch diameter and are used with vee, flat, and timing belt drives.

Now you can prevent minimum machine performance, worn belts and chains due to improper tensioning without going to the trouble and expense of making your own tensioners. Brewer is your convenient low-cost source for all your tensioning needs. Ask your *Power Tensioner Distributor* or write today.

**BREWER MACHINE & GEAR CO.**  
1441-43 N. 2ND ST. ST. LOUIS 6, MO.

Circle No. 11 on Reader Service Card

## POWER TRANSMISSION DESIGN



J. C. SALETTE, JR. ....general manager  
KEITH A. CARLSON .....editor  
STANLEY S. GREENE ....managing editor  
KENNETH MARSHALL ..assistant editor  
HENRY LEFER .....eastern editor  
SCHOLER BANGS .....western editor  
DR. DAVID KINSLER ....distilled writing  
ALARIC MAUSSER .....art director  
N. G. KISER .....circulation manager  
ROBERT GAUVIN .... reader service mgr.

### FRANCHISE DEPARTMENT

LEWIS DAVIS .....representative  
RICHARD PLANCK .....production

### SALES OFFICES

**Cleveland 15**  
812 Huron Rd., SU-1-9620  
ROSS C. TAYLOR

**New York City 17**  
Rm. 836, 60 E. 42 St., MU 7-3420  
LEE HAAS, vice president  
W. E. HORENBURGER

**Chicago 11**  
Rm. 704, 520 N. Michigan, WH 3-1655  
CHARLES F. GEYER, vice president  
ROBERT B. NELSON  
SAM TRACY

**Los Angeles 57**  
Granada Building  
672 S. Lafayette Park Pl., DU 7-5104  
ALAN T. CAZIER, manager

**London, E.W. 1**  
31 Palace St., Westminster, VI 2608  
JOHN A. LANKESTER, manager

### POWER TRANSMISSION DESIGN

is published monthly and copyright 1960 by Power Publishing Company, Inc., a subsidiary of The Industrial Publishing Corporation, 812 Huron Rd., Cleveland 15, Ohio.

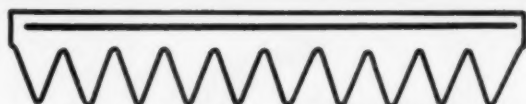
LESTER P. AURBACH .....president  
EDWIN M. JOSEPH .....executive v. p.  
PAUL ROLNICK .....vice president  
N. N. GOODMAN, JR. ....vice president  
LEE HAAS .....vice president  
CHARLES F. GEYER .....vice president  
TOM DEMPSEY .....asst. sec./treas.

**SUBSCRIPTIONS** in U.S. and possessions: \$7. 1 year; \$12. 2 years. Canada: \$8 per year. Foreign: \$10 per year, payable in advance in U.S. funds. U.K.: £3.5.0 per year payable in Sterling to London office. Out of print copies of Power Transmission Design are available in complete volumes as positive microfilm copies from University Microfilms, 313 N. First St., Ann Arbor, Mich.

**AFFILIATED PUBLICATIONS:** Hydraulics & Pneumatics, Material Handling Engineering, Handling & Shipping Illustrated, Modern Office Procedures, Occupational Hazards, Precision Metal Molding, The Refrigeration & Airconditioning Business, Welding Design & Fabrication. Accepted as a controlled circulation publication at Pontiac, Illinois. Return form 3579 to 812 Huron Rd., Cleveland 15, Ohio.

POWER TRANSMISSION DESIGN





POLY-V; continuous strength member



V-BELTS; shorter, interrupted strength member

#### "MORE USE PER DOLLAR"

Poly-V Belt is a single unit with even, uniform pull. Uninterrupted strength member gives much higher hp capacity per inch of drive width. No belt drive delivers as much power in the same space as Poly-V!

## Steel Mill Converts to R/M POLY-V BELT on Rugged Hot-Saw Drive!

A 34½" wide R/M Poly-V® Belt of 92 ribs now delivers "power plus" on this punishing hot-saw drive at one of the country's largest steel works. Converting to Poly-V eliminates the problems of a multiple V-belt drive . . . matching, stretching, overloading, whipping and snapping of individual V-belts.

The patented Raybestos-Manhattan Poly-V Drive is a single unit, V-ribbed belt design that mates perfectly with Poly-V sheave grooves, eliminates V-belt stretch and length matching problems . . . reduces costly machine downtime and production slowdowns for individual belt replacement. Sheave

ratio and belt position remain constant from *no* load to *full* load . . . assure smooth, *complete* power delivery under the toughest drive conditions. Poly-V Belt can't sink in the grooves under surges of load. This means less wear on belts and sheaves . . . and much more power in the same space as a multiple belt drive—or equal power in much less space!

Just two Poly-V Belt cross-sections meet every heavy duty drive requirement. Let an R/M representative show you how Poly-V Drive can give you greater power-packed performance and drive dependability . . . "More Use per Dollar" than the drive you now use. Write for Bulletin M141.

When You Change Drives . . . Convert to R/M Poly-V Drive and Be Sure!

**RAYBESTOS-MANHATTAN, INC.**  
MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY



RM1020  
ENGINEERED  
RUBBER  
PRODUCTS  
... MORE USE  
PER DOLLAR

Circle No. 50 on Reader Service Card

NOVEMBER 1960

volume 2 number 11

# POWER TRANSMISSION DESIGN

THE JOURNAL OF POWER TRANSMISSION

## FEATURE

AC MOTOR SELECTION—PART 1 .....19

## IDEAS

NEW BALL-GALAXY TRANSMISSION DOES HIGH  
TORQUE WORK EFFICIENTLY .....33

GEAR TRAIN ELIMINATES VALVE NOISE .....36

AIR CLUTCHES PAY 500% DIVIDEND .....37

COMPACT V-BELTS REDUCE BEARING OVERHANG .....38

## BEARING SECTION

UNLUBRICATED PLASTIC BEARINGS .....41

## DEPARTMENTS

ADVERTISERS' INDEX .....73      MEN .....14

\*LITERATURE .....69      \*NEW PRODUCTS .....49

MEETINGS .....12      NEWS .....8

READER SERVICE CARD INDEX .....74



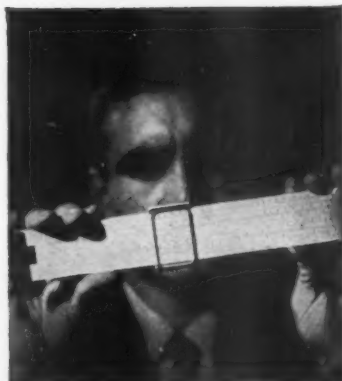
### FACTS AT YOUR FINGERTIPS:

*Before going further, tear out a Reader Service Card which you will find bound into this issue. Fill it out as you read and mail it when you're done. We'll act on your request immediately.*

WHATEVER YOUR NEEDS . . .



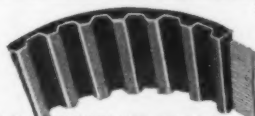
# Here's Industry's MOST COMPLETE LINE OF QUALITY V-BELTS



## DA 358 V-BELTS



For highly compact, plus-power drives. First major design change in Multiple V-Belts in the last 30 years.



## DA POSITIVE DRIVE BELTS

Combines the advantages of the chain and gear with all of the advantages of the belt. No stretch, no metal to metal contact, no constant lubrication.

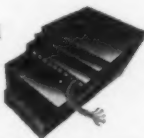
## STURDY-LINK

Pre-stretched link belting available in regular, oil-resistant and static-conductive types.



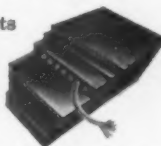
## GENERAL DUTY V-BELTS

Power-balanced construction for flexibility, durability and strength.



## STEEL CABLE V-BELTS

Steel cable permits no-stretch installation. All belts are fluoroscoped to assure extra high quality.



## RAILROAD BELTING



High tensile strength, low stretch belting features high fastener tear-out resistance.



## DOUBLE V-BELTS

Relieved cross section assures maximum flex resistance. New control methods provide uniform cord section.

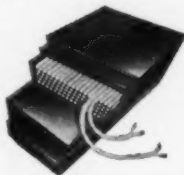
## OPEN END V-BELTING



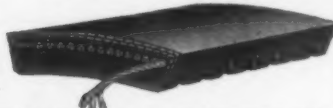
Used on drives where endless V-Belts are not practical. High fastener tear-out resistance.

## RED SHIELD MULTIPLE V-BELTS

Red Shield Belts now offer 40 per cent extra capacity. Iso Dynamic matching and cord stability assure precise balance and long belt life. Also available in oil and heat resistant and static dissipating constructions.



## VARIABLE SPEED BELTS



Abrasion resistant cover assures maximum life. Crowned cross section maintains stability under extreme loads.

Test . . . Compare . . . You'll Select

# DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY • MINNEAPOLIS 13, MINNESOTA

Look for the  on your V-Belts

Circle No. 23 on Reader Service Card

# THE MAN & THE GEARING





# FROM WESTINGHOUSE

Change gear ratios right in your own plant . . . Mr. Westinghouse† and Moduline gear units bring simplicity and versatility to gearing applications

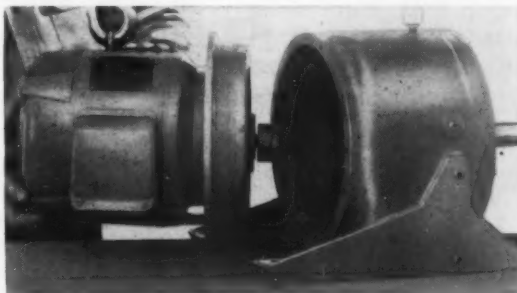
The modular design of Westinghouse Moduline\* drives saves you time and money. Now you can change gears right in your own plant to take advantage of changing manufacturing techniques or improved processes. No more delays . . . Moduline never becomes obsolete, always permits rearranged configuration rather than expensive replacement.

And maybe you've already heard that we've stepped up our application assistance and manufacturing and delivery pace, too. We've moved our entire gearing department to the Buffalo Motor Plant to assure fast and complete coordination on any drive problem you may have. For any drive application, call *your* Man from Westinghouse. He's a drives expert well equipped to represent our Buffalo Division, industry's "controlled torque" headquarters. You can be sure . . . if it's Westinghouse.

†Gil Wilson, Sales Engineer, Hartford Office.

\*Trade-Mark  
J-07371-R

One standard wrench is all you need to modify any Moduline unit. Gear pullers have been completely eliminated, and no special aligning or positioning of modules is necessary during assembly.



Westinghouse



**READY  
TO  
INSTALL!**

**GLOBE  
Hardened Steel  
MITER GEARS**

**Complete with  
Keyway and set screw**



Globe's new HMK Miter Gear Series eliminates additional machining and costly delays.

**FROM STOCK  
4 to 16 PITCH**

Available through  
Leading Power Transmission  
Distributors

**GLOBE STOCK GEAR DIVISION  
34TH AND CLEARFIELD STREETS  
PHILADELPHIA 32, PA.**

Circle No. 32 on Reader Service Card

8

**NEWS** from the power transmission field

**"Industrial cooperation"  
aim of 1961 SAE meeting**

NEW YORK, N. Y.—Industrial cooperation will be the underlying theme in the International Congress and Exposition of the Society of Automotive Engineers, to be held in the Cobo Hall, Detroit Jan. 9th to 13th, 1961.

Upwards of 15,000 automotive and aeronautical engineers will gather to hear 175 technical papers on a wide variety of topics, during the 73 sessions. These will range from the design, development and operation of passenger cars, trucks, buses, transport aircraft, missiles, farm tractors, earth-moving equipment and space vehicles, to propulsion devices, materials, production and fuels and lubricants.

The SAE believes that meetings and displays highlighting the latest scientific discoveries and developments in one industrial area will stimulate thinking in other fields, as

well as suggesting ways to save time and money.

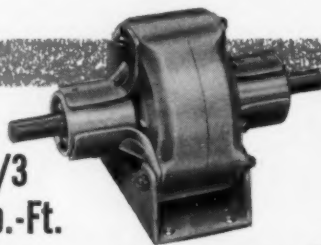
**Blank stamping process  
eliminates shaving**

TROY, MICH.—A new high speed stamping process called the Hydro-Cam Smooth Edge blanking process produces precision stamped blanks with straight smooth edges in a single operation.

Developed by Hydro-Cam Engineering Co. of Troy, Mich., the one-stroke operation produces a surface finish comparable with grinding and is accurate to .0005 in. Either coil or strip stock can be used. Special dies in the high speed hydraulic press hold the material firmly clamped during the shearing sequence, preventing flowing or tearing along the line of shear.

The process has been successful with steel parts of various hardnesses,

**VICKERS  
SLASHES PRICE 1/3  
on the New 10 Lb.-Ft.**



**MAGNECLUTCH<sup>®</sup>  
DRY MAGNETIC PARTICLE CLUTCH**

**Substantial Improvement in Reliability, Service Life**

This new low-cost, lightweight Magneclutch retains and improves all the outstanding characteristics of the older model: no wear on torque transmitting surfaces, smooth operation, torque at zero slip, etc. Larger size Magneclutches available to 200 lb.-ft., water or air cooled.

Watch for Announcement of  
New 5 lb.-ft. Magneclutch

Write for New Bulletin 6106-5  
on Vickers 10 lb.-ft. Magneclutch

**VICKERS INCORPORATED  
DIVISION OF SPERRY RAND CORPORATION  
ELECTRIC PRODUCTS DIVISION**

1837 LOCUST STREET / SAINT LOUIS 3, MISSOURI EPA 6100-5

Circle No. 62 on Reader Service Card

**POWER TRANSMISSION DESIGN**

# *FAST off-the-shelf delivery*

## **MORSE EBERHARDT-DENVER CONVEYOR DRIVES**



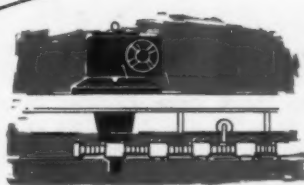
- \* No design limitation . . . up, down, or 90° mounting
- \* one-piece alloy cast iron housing \* high torque capacity \* single or double reduction gears \* input ratings from .12 hp to 53.72 hp using double worm reduction or helical worm reduction \* ratios from 5:1 up to 3600:1 — from stock at low factory prices.

### **Easy-mount design... only 4 bolts**

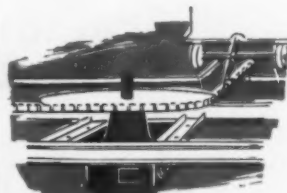
Morse E-D speed reducers lead in limitless applications with utmost ease in mounting. The 4 holes form a perfect square concentric to the output shaft. Unlike most designs, Morse E-D speed reducers feature oversize bearings on wide centers . . . resulting in an overhung load capacity at the end of the output shaft equal to the torque capacity.

Mounting versatility with the unit's cast-in base makes Morse drives adaptable to conveyors of all types, agitators, screw conveyors, machines, and for any other transmission of power where dependable speed reduction is specified.

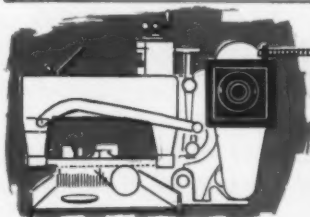
You'll find Morse "standard" drives ready for immediate delivery . . . often eliminate the problems of "specials." Check with your Morse distributor, he's listed in the Yellow Pages under "Power Transmission," or write Morse Chain Company, Dept. 27-110, Ithaca, N. Y. for illustrated catalogs. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.



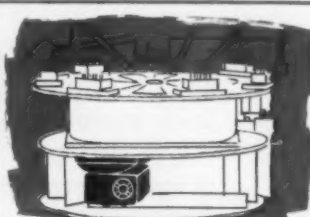
**OVERHEAD** . . . typical caterpillar or sprocket drives



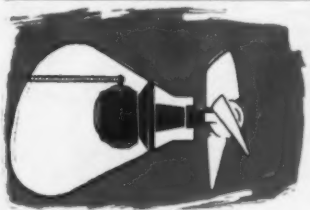
**SUB-FLOOR** . . . for towline or special equipment



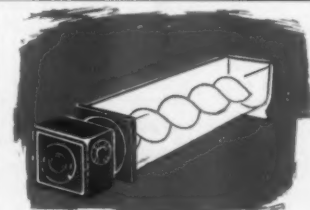
**90° MOUNTING** . . . for heavy-duty metal saws and machines



**VERTICAL** . . . base mounting for power turntable machines



**SIDE MOUNTED** . . . paint, pulp, liquid, or chemical agitators



**HORIZONTAL** . . . screw conveyors, straight or angular mounts . . . and scores of standard or special uses.

# **MORSE**

**BW**

T.M.

**A BORG-WARNER INDUSTRY**










## AGREED! BOND IS BEST!

**For Power Transmission Equipment**—Power transmission users and designers know Charles Bond as the best and most dependable source of stock power transmission equipment. Bond's almost three quarters of a century of experience in manufacturing power transmission equipment has made it routine to specify Bond products for a great number of applications.

Bond's large factory and distributor stock provide an ideal "instant" source for new and replacement power transmission equipment.

CHECK WITH YOUR NEAREST BOND DISTRIBUTOR, or contact Charles Bond Company for all your power transmission applications for:

 SPEED REDUCERS	 GEARS	 SPROCKETS AND CHAINS	 FLEXIBLE COUPLINGS	 UNIVERSAL JOINTS COLLARS PILLOW BLOCKS
-------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------

**Carried in stock by  
Distributors in  
Principal cities**

Write for free catalog No. 100

**CHARLES BOND COMPANY**

617-23 ARCH STREET • PHILADELPHIA 6, PENNSYLVANIA

Circle No. 12 on Reader Service Card

## NEWS continued

and with brass, aluminum and copper. Thin precision parts from .010 to 3/16 in. thick and thicker, with several holes, have been made with smooth holes and edges.

## Michigan Tool adds to gear shaper line

**DETROIT, MICH.**—Two new models in the Shear-Speed line of gear shapers are offered by Michigan Tool Co. Called the 3000 Series, the twin column machines come in two sizes: Model 3053 for gears from 3 to 5 in. and the 3073 for gears from 5 to 7 in.

Principle of operation is same as for earlier 1800 Series. Multiple single point tools feed toward the center while the work reciprocates up and down to produce all teeth or forms on the contour simultaneously.

Advantage of the 3000 Series is that twin column construction with integral crosshead at the top permits chip removal through rear of machine. New design provides improved alignment of vertical cutting forces, important when cutting coarse pitch wide face gears, such as pump gears. Cutter heads, fixtures, tooling, etc. are interchangeable between the new Series 3000 and Series 1800.

## New Delroyd Co. to sell reducers on West Coast

**MILLBRAE, CALIF.**—Delroyd Co., a combination of De Laval Steam Turbine Co. and John Holroyd & Co., Ltd. of England, is establishing a distribution network for its worm gear speed reducers throughout the West Coast area. These reducers use the involute helicoid tooth form and rate 84 per cent efficiency at reduction ratios of 60 to 1. They will be made at the newly acquired plant at Trenton, N. J.

Harvey Finch, De Laval worm gear specialist, will head the distribution system.

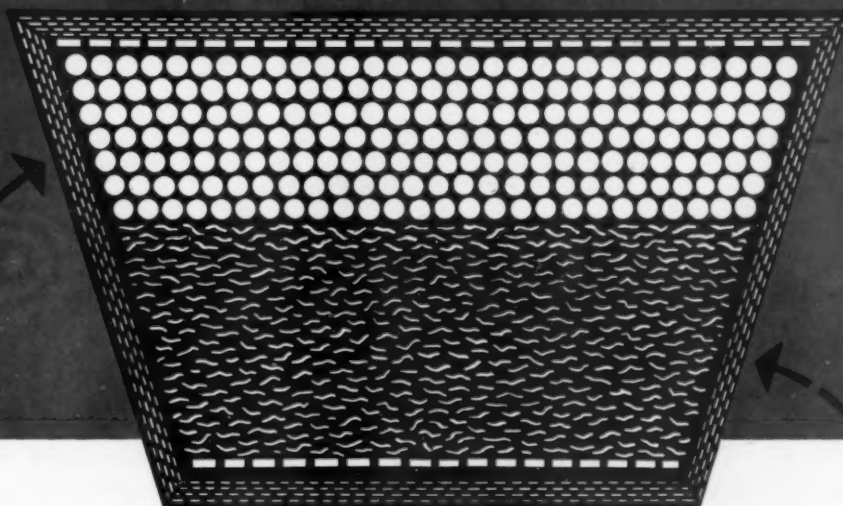
## Boston appoints Te-Co

**BOSTON, MASS.**—Te-Co, Inc., of St. Louis, Mo., has been appointed a warehousing distributor for Boston Woven Hose & Rubber Div., American Bilrite Rubber Co.

POWER TRANSMISSION DESIGN



# Only BOSTRON V-Belts



*are made with...*

## BOSTRON Tensile Members

**PLUS**

## NEOPRENE with FIBER-DISPERSED Stock

**GREATER STABILITY** — Changes in humidity — and the resulting moisture regain — often mean a matching problem with ordinary V-Belts. The moisture regain of BOSTRON is low — 0.4% — or 1/20th that of the conventional reinforcing fiber. This means far less time spent in matching, and lower belt inventory too.

**HIGHER STRENGTH** — Stronger belts can withstand more shock loading, need less maintenance. BOSTRON is approximately 40% stronger than the conventional fiber used in V-Belts.

**STRETCH RESISTANCE** — V-Belts reinforced with BOSTRON have low stretch. BOSTRON is inherently stretch-resistant and the cords are put through a special heat and tensioning process to further minimize stretch. Thus, belts reinforced with BOSTRON show comparatively little growth — even after many months of continued operation.

**GREATER RESISTANCE** to oils, heat, abrasion, chemicals and ozone is provided by Neoprene.

**HIGH CROSS-WISE RIGIDITY** is provided by the closely-packed, straight-line formation of the fibers in the compression member.

**EXCEPTIONAL LENGTH-WISE FLEXIBILITY** is provided by the virtually frictionless positioning of fibers.

**EXTRA SUPPORT** for the tensile members during shock-load impact and during normal operation.

The industry's most advanced developments are now standard in the entire BOSTON Multiple V-Belt line!

- CUT DOWN MAINTENANCE
- MAINTAIN SMALLER INVENTORY
- SAVE MATCHING TIME
- SAVE TAKE-UP TIME

**BOSTON**

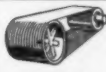
BOSTON WOVEN HOSE & RUBBER COMPANY  
DIV. OF AMERICAN BILTRITE RUBBER CO., INC.  
BOSTON 3, MASS.



INDUSTRIAL HOSE



BELTING



V-BELTS



PACKING



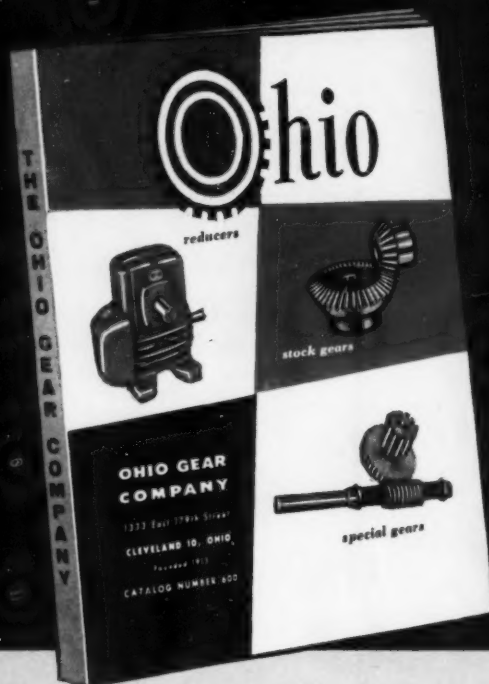
MATTING



TAPE

Circle No. 10 on Reader Service Card

Here it is . . . the **NEW**  
**OHIO GEAR**  
**Catalog**  
 246 pages on gears  
 and speed reducers



The new OHIO catalog—246 pages packed with useful engineering data, sizes, ratings and specifications on one of industry's most complete line of gears and speed reducers.

. . . new convenient size . . .  
 clearly indexed . . . spiral  
 bound to lay flat . . . fully  
 illustrated . . . complete and  
 unabridged.

**WRITE FOR YOUR COPY TODAY!**

Please use your company  
 letterhead and specify  
 your title or occupation.

**CONTENTS:**

**Speed Reducers**

- Reducer Classifications
- Engineering Data
- Installation & Maintenance
- Selection Chart
- Reducers by type and size

**Gears**

- Stock Gear Lists
- Rules for figuring
- Tooth Data
- Ratings

**Sprockets**

- Engineering Data & Tables



**OHIO GEAR CO.**

1327 East 179th Street • Cleveland 10, Ohio

Circle No. 46 on Reader Service Card

NEWS continued

**Wear and friction tester  
 now available**

DAYTON, OHIO—A tester that simulates combinations of wear, heat and atmospheric conditions for evaluating bearings, rings and cylinders and all types of metals and alloys, is being produced by the Hohman Plating & Mfg. Co. It uses diametrically opposed rub blocks against a Timken test cup. The torque resulting from friction is measured by a strain gauge dynamometer. Thermocouples show the temperatures developed in each rub shoe. With auxiliary equipment, ambient temperatures can be varied from -60 F to 1500 F, with connections for introducing gases and controlled humidity atmospheres. It's also possible to completely immerse specimen and rub shoes in a bath of molten metal for special tests. The tester can also be used for friction measurements of solid lubricants, plastics and fibrous materials as well as oils and greases.

**ASTM lists 1959 references  
 on fatigue**

PHILADELPHIA, PA.—The American Society for Testing Materials has compiled a book of references on articles published in 1959 that deal with fatigue of structures and materials. Covering 88 duplicated pages, the book's 460 entries provide an extensive source of information. An abstract of each reference is included in most cases. Sponsored by an ASTM committee on fatigue, copies may be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at \$4 each.

**MEETINGS**

**NOVEMBER**

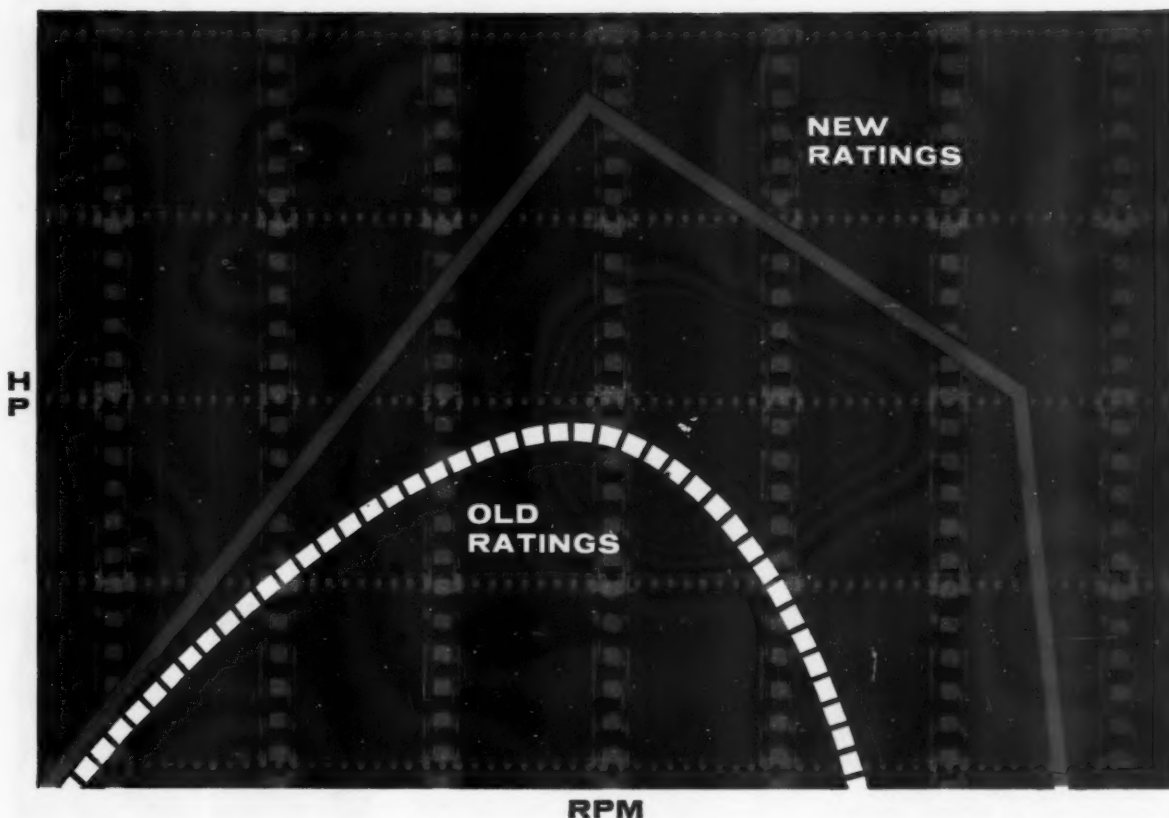
27-

Dec. 2 American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York.

**JANUARY 1961**

9-13 Society of Automotive Engineers, Annual Meeting, Cobo Hall and Convention Arena, Detroit

POWER TRANSMISSION DESIGN



## NEW HORSEPOWER RATINGS FOR REX ROLLER CHAIN

**Break the Barriers on Speed and Capacity**

Now you can use Rex Roller Chains for efficient operation at horsepower capacities and speeds generally considered impractical in the past. New ratings, made possible by quality improvement and proved in the most exhaustive laboratory and field tests, now open fields of application for the imaginative designer.

The new horsepower ratings were developed by the combined efforts of the Association of Roller and Silent Chain Manufacturers. Rex Engineers took an active part in this program. Here are the facts:

### PRODUCT IMPROVEMENT PROGRAM

For some time, Rex Engineers have been engaged in a program of continuous product improvement. Such developments in design and manufacturing as guided piercing and re-piercing of link plate holes...precise control of pin, bushing and roller diameters...precision interference fits of pins and bushings in link plates...accurate control of pitch...oil holes in bushings for increased access of lubrication to live bearing areas...have resulted in greater horsepower capacity for Rex Roller Chains.

### APPLICATION EVALUATION PROGRAM

Through years of extensive work both in conjunction with the Association of Roller and Silent Chain Manu-

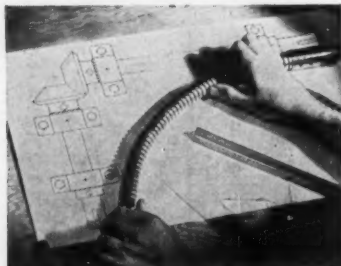
facturers, and in CHAIN Belt laboratories and in the field, Rex Engineers have helped acquire a more intimate knowledge of the load and speed requirements of roller chains under actual service conditions. Such testing programs as field dynamic load tests using strain gauges on actual operating chains...the relationship of proper lubrication and speed as it affects galling...have led to successful applications of Rex Roller Chains at greater loads and speeds than previously considered practical.

**For all the facts** and your copy of the new horsepower ratings, write CHAIN Belt Company, 4734 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: CHAIN Belt (Canada) Ltd., 1181 Sheppard Ave. East, Toronto.

# REX<sup>®</sup>

**CHAIN BELT COMPANY**

## SOLVE POWER TRANSMISSION PROBLEMS WITH STOW FLEXIBLE SHAFTING



### THE EARLY STAGE IS THE TIME OF DESIGN PLANNING TO CONSIDER STOW FLEXIBLE SHAFTING.

Flexible Shafting can solve many complex power transmission problems normally encountered in transmitting power through a curved path or between components which have relative motion most efficiently, and more economically.

Use of standard or specifically designed power drive flexible shafting reduces or eliminates alignment and maintenance problems . . . does away with complex and expensive arrangements . . . removes danger of exposed moving parts.

#### CHECK THESE ADVANTAGES:

- **Simplicity of Design**—greater freedom to locate components . . . ideal for connecting components having relative motion.
- **High Efficiency**—ranging from 80% to 95%.
- **Safety**—replaces exposed universal joints and shafts in hazardous locations.
- **No Alignment Problems**—accuracy of alignment, so important on conventional drives, is not required.

When next you have a specialized power transmission problem . . . check with STOW before designs have advanced too far. STOW engineers are ready to help you.  
Write for Engineering Bulletin No. 570 and a free torque calculator.

**STOW**  
MANUFACTURING CO.  
440 Shear St., Binghamton, N. Y.

Circle No. 54 on Reader Service Card

## MEN of the power transmission field

### Donald Fraser, Garlock vice president, dies

PALMYRA, N. Y.—Donald F. Fraser, vice president-manufacturing of Garlock, Inc., died of heart attack on Sept. 12, after suffering an initial attack some days earlier. Fraser, a

chief engineer, works manager and production manager, becoming vice president in 1957.

Before coming to Garlock, he was vice president and general manager of Rodic Chemical and Rubber Corp. in New Jersey. He was also a director of the New York Rubber Group, and a member of ACS and ASME.



FRASER

Canadian and a graduate of Toronto University, joined Garlock in 1954 and successively served as acting

### Timken appoints two

CANTON, OHIO—R. L. Frederick, formerly executive director of International Divisions, is elected vice



GULLING



FREDERICK

## We bet millions on our couplings



When you buy a Fast's coupling, you can bet your bottom dollar everything was built on the spot, not assembled piece by piece from other suppliers. Koppers multi-million dollar manufacturing facilities are the most modern in the industry . . . with advanced program machines, highly accurate gear shapers, a complete forge shop.

For example, all Fast's Couplings are jig-drilled and jig-reamed for greater interchangeability of parts. Result: you get high-quality, smooth-running, long-lived units that are the choice of more equipment manufacturers than any other gear-type coupling.

KOPPERS COMPANY, INC., 911 Scott Street, Baltimore 3, Md.



## FAST'S COUPLINGS

Engineered Products Sold with Service

Circle No. 39 on Reader Service Card

POWER TRANSMISSION DESIGN



# New

## ROTO-MISSION

TRADE MARK



**Most versatile  
transmission  
ever developed!**

**ONLY ROTO-MISSION GIVES YOU  
ALL THESE FEATURES**

- Concentric configuration
- Minimum size for a specified torque
- Reduction ratios up to 270:1
- Optional torque capacities for each reduction ratio
- Torques up to 21,850 lb.-ft.
- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
- Reversible
- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- \*Ability to engage or disengage driving action—mechanically, pneumatically, hydraulically or electrically
- \*Ability to provide load releasing, load limiting or overload alarm
- \*Ability to provide 2-speed operation

\*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions—may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you—write today for Catalog IR-60.



*Engineered Equipment for Aircraft and Industry*

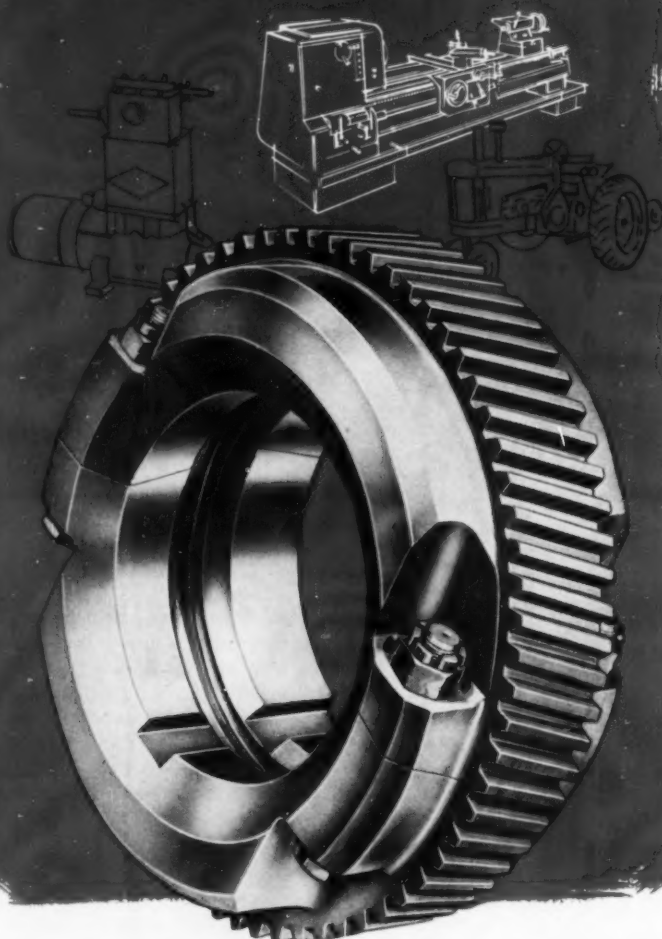
**AIRBORNE ACCESSORIES CORPORATION**

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

Circle No. 2 on Reader Service Card

# Whatever the product...

"Worthy" names go together...  
yours and **CINCINNATI GEAR**



This trademark on a gear is the **GUARANTEE** of a quality-conscious gear manufacturer.

**CINCINNATI GEAR** has kept in the forefront of technological progress in gear-making methods and equipment for over 50 years. The oldest "tool" in our ultra-modern shop is *pride in true craftsmanship!*

Send us your prints for quotation.



## THE CINCINNATI GEAR CO.

Mariemont Ave.

Cincinnati 27, Ohio

Custom Gear Makers Since 1907

**GEARS, good gears only**

Circle No. 14 on Reader Service Card

### MEN continued

president in charge; and R. A. Gulling, the company's assistant treasurer takes up the additional post of controller.

Frederick, who came to Timken as a factory trainee in 1940, has held various posts from grinder and assembler in 1941 to director of industrial relations in 1958. He holds degrees from Pennsylvania State and M.I.T.

Gulling, an IBM operator in 1943, was graduated from Notre Dame and has attended the Harvard Advanced Management Program. A certified accountant, he will co-ordinate the company's world wide accounting system.

### Keefer vice president controller at Warner

BELOIT, Wis.—William W. Keefer has been named vice president controller of Warner Electric Brake & Clutch Co.

*In our October issue we reported incorrectly that Mr. Keefer had been appointed president controller. The president of Warner Electric is Steven P. J. Wood. Our apologies to both.*

### Clark joins Eaton

CLEVELAND, OHIO—Edgar W. Clark, formerly president of Clark Marketing Co., has joined Eaton Mfg. Co. as director of marketing research. He



CLARK

succeeds Sydney E. Cowlin who resigned recently after 20 years with Eaton to enroll as a divinity student.

As head of the Clark Marketing Co., he made an extensive survey of the small boat industry in connection with Eaton's new Powernaut Marine Drive which the company is preparing to produce.

Circle No. 15 on Reader Service Card →



# cullman



## cullman

### Sprockets and Roller Chains

the big **3-A LINE** in the  
Power Transmission Field



**1 ACCURACY IN MANUFACTURING . . .**  
Cullman Sprockets and Roller Chains are manufactured to precise and exact standards, subjected to constant quality control inspection.

**2 ADAPTABILITY IN APPLICATION . . .**  
Cullman Sprockets and Roller Chains are efficient, flexible, dependable for a virtually unlimited range of power transmission needs.

**3 AVAILABILITY IN SUPPLY . . .**  
Cullman Sprockets and Roller Chains are stocked by leading industrial distributors.

**FACTORY WAREHOUSES AT:**

821 South Santa Fe Ave., Los Angeles 21, California  
239 West 18th St., New York 11, New York  
2618 Carnegie Ave., Cleveland 15, Ohio  
205 North 11th St., Tampa 2, Florida

*Roller Chain Drives Since 1893*

**cullman wheel company**

1344 Altgeld Street • Chicago 14, Illinois

**WRITE** today for latest free literature  
. . . plus recommendations for your  
chain drive requirements.

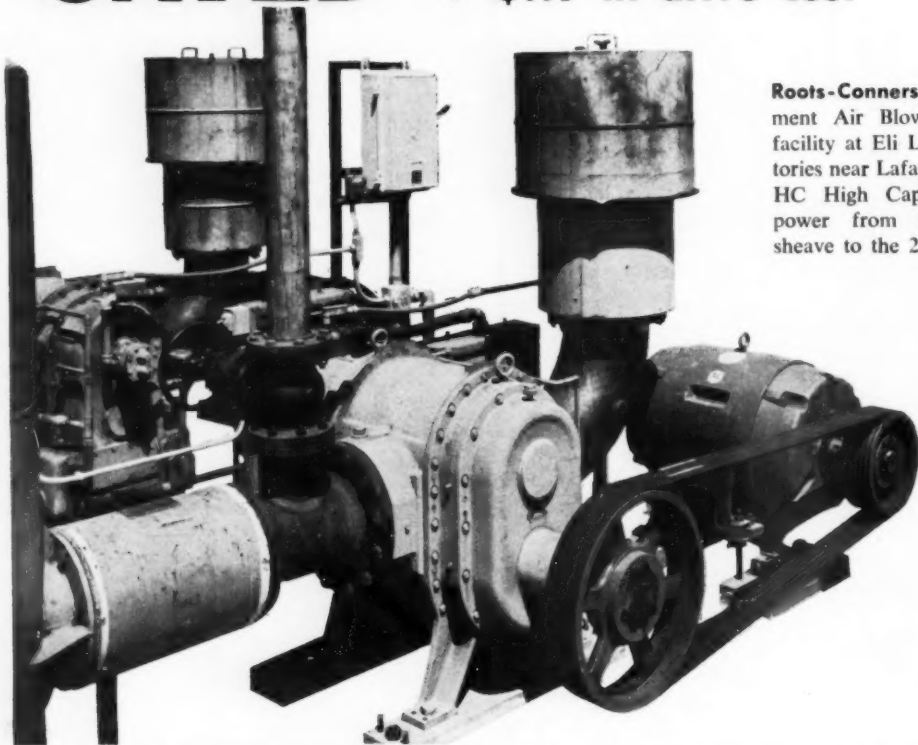


# wheel

# Gates High Capacity Drive on Blower for Eli Lilly

# SAVED

**{ 67/8" in face width  
97 lbs. in drive weight  
\$119 in drive cost**



**Roots-Connorsville** Positive-Displacement Air Blower on waste-treatment facility at Eli Lilly Company's Laboratories near Lafayette, Indiana. Six Super HC High Capacity V-Belts transmit power from the 13.2-inch DriveR sheave to the 21.2-inch DriveN.

For each blower that Roots-Connorsville supplied for the Lilly Laboratories at Lafayette, Indiana, original drive specifications called for 11-groove sheaves using standard belts.

Because 11-groove sheaves were special and time was short, the original drive specifications were re-examined. Could Gates Super High Capacity V-Belt Drives handle the installation better?

They could — and did. Instead of 11-groove drives, regular 6-groove Super HC Sheaves and Super High Capacity Belts were shipped from stock . . . arrived at

the job overnight . . . saved the situation — as well as time, money, space and weight.

#### For all users of multiple V-belt drives . . .

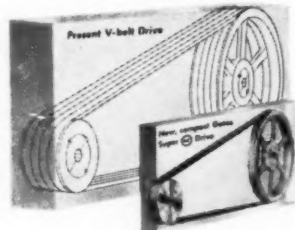
Gates Super High Capacity V-Belts offer similar opportunities to save. These Super HC Drives pack the same hp capacity into smaller space — require fewer belts, smaller sheaves, shorter center distances. The helpful design handbook "*The Modern Way to Design Multiple V-Belt Drives*" is yours for the asking. Just ask your Gates Field Engineer, listed in the Yellow Pages in the nearest industrial center.

TPA538A

**The Gates Rubber Company, Denver, Colorado**  
Gates Rubber of Canada Ltd., Brantford, Ontario



World's Largest Maker of V-Belts



# Gates Super V-Belt Drives

same hp capacity  
in smaller "package"

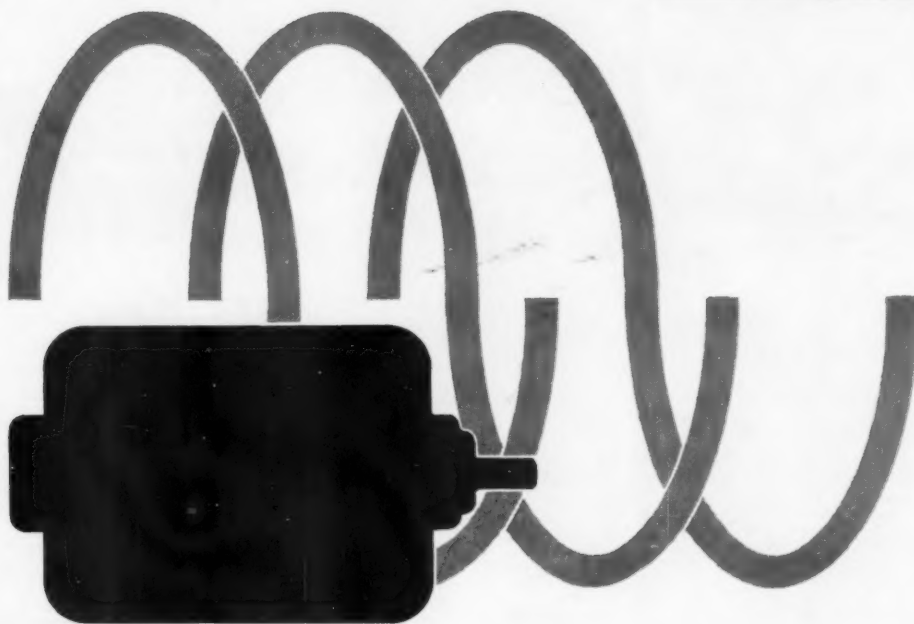
Circle No. 29 on Reader Service Card



# AC Motor Selection

POWER  
TRANSMISSION  
DESIGN

NOVEMBER 1960



## Part 1-Characteristics of Polyphase Types

### ● Squirrel Cage

### ● Wound Rotor

### ● Synchronous

MANY PROBLEMS in power transmission system design are the result of prime mover, or power source, characteristics. It's certainly true, then, that picking the right power source can reduce cost or complexity of the whole power transmission system, or both.

Because ac is so widely available in homes, offices and factories, the most widely used power sources are ac motors. This article will cover basic speed, torque and horsepower characteristics of ac motors, as well as important physical characteristics and construction variations.

Generally, the application determines whether an ac motor should be single-phase or polyphase. Current available in homes and offices is single-phase. Therefore, motors to be used in these locations must be single-phase. In industrial plants, polyphase current is available, as well as single-phase. For most applications, this means polyphase motors are used in industrial plants.

In most instances, polyphase and three-phase are synonymous. However, there are certain areas of the country where two-phase power is supplied by the power companies. Almost all manufacturers of three-phase motors will provide identical motors for two-

phase operation. Frame size, speed, horsepower, and characteristics are identical.

There's a type of two-phase motor, the servo motor, which is commonly controlled by electronic amplifiers. Also, it's a small-output motor, more closely related to some of the single-phase motors than the majority of those to be discussed here. For this reason, servo motors will be discussed in Part 2—Single-Phase AC Motors.

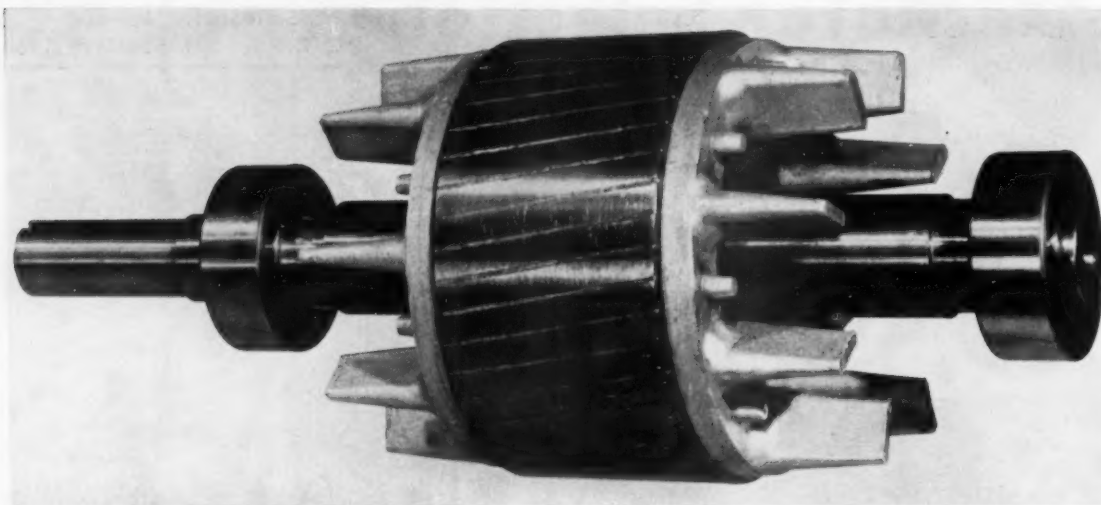
Polyphase motors are, in general, smaller, less complicated, and less costly than single-phase motors of equal horsepower. This accounts for their popularity where they can be used. There are three kinds of polyphase motors. They are:

1. Squirrel-cage induction motors
2. Wound-rotor induction motors
3. Synchronous motors

The motors will be discussed in this order.

### Squirrel-Cage Induction Motors

This type of motor is mechanically the simplest motor made. There are no brushes, slip rings, or centrifugal switches to wear or need adjustment. The only wearing parts are the shaft support bearings.



**FIGURE 1.** Typical cast squirrel-cage motor rotor construction. Rotor may also be fabricated from bars connected to end rings. Photo, courtesy Westinghouse Electric Corp.

#### AC MOTOR SELECTION *continued*

The rotor is a number of bars connected together by rings at both ends. This construction is the squirrel cage which gives these motors their name. The rotor may also be cast as a single unit with bars and end rings, Fig. 1, or fabricated. There are no electrical connections to the rotor.

The stator, or field, is wound in conventional fashion with wire windings placed in slots of stacked laminations of electrical iron or steel.

#### Performance Characteristics

Rotation in these motors is caused by rotation of the magnetic field in the field windings. This rotation occurs because of the increasing and decreasing currents in the three-phase field winding. The rotor is magnetized by the magnetic field set up by the field and tries to revolve at the same rate. This establishes the maximum speed at which these motors can operate with a given supply frequency. If only one set of windings (one pair of poles) is used in the field, the magnetic field physically revolves 360 deg during one current cycle. For 60 cps ac this means the maximum speed is 60 rps or 3600 rpm.

The number of windings, or poles, may be increased to decrease the speed. This, however, means that for a given hp, the motor becomes bigger as output speed decreases.

This inherent limitation of maximum speed of squirrel cage motors is what's responsible for the development of motors to operate on 400 cps and higher frequency ac. The 400 cps motor has maximum speed of 24,000 rpm, with one pair of poles. The speed increase results in considerable weight and size reduction, Fig. 2. To date, use of 400 cps motors is usually



**FIGURE 2.** Where size, weight, or high speed are extremely important, high-frequency squirrel-cage motors can be used. This 1-hp, 22,000-rpm unit is obviously very much smaller than a 60-cps motor of equal power. Photo, courtesy Hoover Electric Co.

confined to aircraft and missiles because the size and weight reduction doesn't justify the cost of the 400 cps power supply in industrial applications.

Speeds talked about so far are the maximum theoretical, or synchronous, speeds of squirrel-cage motors. Actually, these motors cannot operate at these speeds because the rotor is not magnetized unless the bars are cut by field flux. This requires some relative rotation. The difference between synchronous speed and the speed at which the rotor actually operates to provide the required torque is called *slip*. Amount of slip during normal operation depends on the speed-torque characteristics of the motor. These can be varied by design to suit particular types of applications.

Several types of speed-torque characteristics are available. These have been standardized by NEMA (National Electrical Manufacturers Association). Motor torque is largely controlled by the resistance of the rotor bars.

## Designs A and B

Most commonly used type of squirrel-cage motor is NEMA Design B. Its torque characteristic, Fig. 3a, may be thought of as normal for squirrel-cage motors. Starting current draw is low. NEMA specifications for these motors allow variations in locked-rotor torque and breakdown torque for different motor sizes. Locked-rotor torques specified by NEMA range from 275% of full-load torque for 1-hp motors to 100% for 200 hp. These values also vary with synchronous speed of the motor. Breakdown torques vary from 200 to 300% of full-load torque. Slip of design B motors is less than 5% at rated load.

There are also NEMA Design A motors. These are not as widely used as Design B because they have higher starting or inrush current, Fig. 4. This, in many cases, means more expensive starting equipment must be used. Advantage of this motor is its better speed regulation—the ability to maintain nearly constant speed despite load torque variation. Price of Design A motors may be somewhat higher than the Design B since Design A is not so widely used.

Torque-speed characteristics of Design A and B show that they can accelerate any load they can start up to normal operating speed. These are essentially constant-speed motors since torque may vary from full load to roughly 200% of full load without reducing speed below 85 to 90% of synchronous speed. As already pointed out, Design A has more constant speed than Design B.

**Applications:** These motors are used in a multitude of jobs where their constant-speed characteristic is desirable. Included are: driving centrifugal pumps, positive-displacement hydraulic pumps, machine tools, blowers, fans, and agitators. They are also used in many cases where constant speed is not desirable, because of their low cost, and reliability. In such instances, they drive some sort of speed-changing device.

## Design C

Where starting torque requirement is higher than designs A or B can provide, NEMA Design C motors may be used. Their speed-torque characteristic, Fig. 5, shows that starting torque is considerably higher than at any other point in the operating range.

Locked-rotor torques range from 200 to 250% of full load. Breakdown torques are from 190 to 200% of full load. These figures are for motors from 1/2 to 200 hp operating at synchronous speeds of 1800, 1200, and 900 rpm on 60 cps current, and 1500, 1000, and 750 rpm on 50 cps. Full-load slip is less than 5%.

**Applications:** These motors are used primarily for driving compressors—which includes refrigeration devices—conveyors, reciprocating pumps, and other types of machines which start under fairly heavy load.

## Design D

This design variation of the squirrel-cage motor develops higher starting torque than any other type. NEMA specifies that starting torque shall be 275%

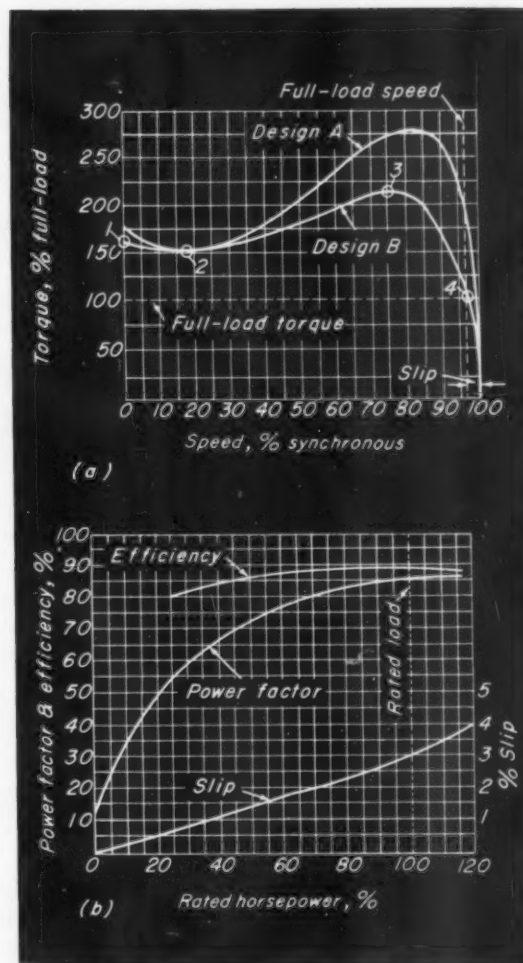


FIGURE 3. Speed-torque characteristics of NEMA Design A and Design B motors, (a). Labelled points (1, 2, 3, 4) are: 1. Breakaway, starting, or locked-rotor torque; 2. Minimum, or pull-up, torque; 3. Maximum, or pull-out torque; 4. Full-load point. Courtesy, Sterling Electric Motors. Efficiency, power factor, and slip are shown at b. Courtesy, Lincoln Electric Co.

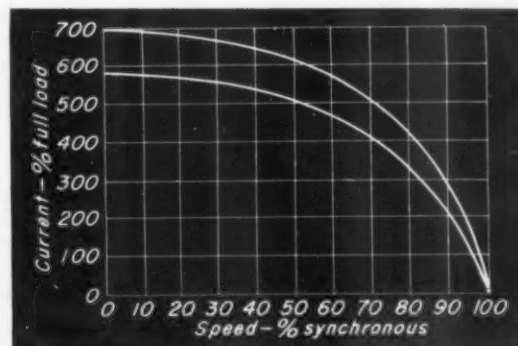


FIGURE 4. Current draw of Designs A and B compared.

of full load torque and that slip at full load is more than 5%. Within these limitations, the variation shown by the curves in Fig. 5 is possible. Motors with the higher torque curve have slips at full-load rpm from 8 to 13%. Those with the lower torque have slips from 5 to 8%.

These motors are sometimes called punch-press motors because their characteristics fit them to continuous operation with fluctuating load. They are also well suited to applications where there are frequent starts and stops. A comparison of the current-speed curves of Design B and Design D motors, Fig. 6 shows why this is so. Current during the acceleration period from zero to full-load speed is always less for the Design D motor. Motor heating during acceleration is roughly proportional to the square of the current. Therefore, the Design D motor is producing less heat at any point along the curve and, additionally it spends less time accelerating due to its torque characteristic.

**Applications:** As previously mentioned, these motors are often used on punch presses. Which of the two variations to use depends on the frequency of cycling. On jobs where there are only a few strokes per minute, the 8-13% slip motor is best. The 5-8% slip motor is best for about 15 to 45 strokes per minute. At higher stroke frequencies, inertia of the mechanical system makes load on the motor nearly constant and a standard design motor will do.

Other typical uses are on cranes, hoists, elevators, machine tools, and oil well pumps.

### Design F

Though a standard NEMA design, these motors are considered to be special purpose motors. Torque, Fig. 5, is lower than Design B motors at all points but full load. Starting current and slip are also low. Of all the squirrel-cage motor types, this one is best suited for jobs where torque requirement is highest at full-load speed. Fans and compressors with unloading devices are typical.

## Multispeed Squirrel-Cage Motors

Where a job demands more than one fixed speed, there are multispeed squirrel-cage motors which will provide 2, 3 or 4 speeds. These speeds are submultiples of normal synchronous speeds. Speed ratios available are generally limited to 4:1. That is, if high speed is 1800 rpm, the other speed could be no lower than 450 rpm.

More than two speeds are gotten only from double-winding motors. From such motors, a combination of speeds such as 1800, 1200 and 900 rpm can be had. These motors are necessarily larger and heavier than either single-speed or two-speed motors.

Multispeed motors are available with constant-torque, constant-horsepower, or variable torque. The constant-torque motor delivers the same torque at any speed. Thus, if it delivers 10 hp at 1800 rpm, it

would deliver 5 hp at 900 rpm. The constant-horsepower motor produces torque inversely proportional to its speed. That is, at 900 rpm, torque would be twice what it is at 1800 rpm. In the third design, the variable-torque motor, both speed and torque decrease in the same proportion. Therefore, a 10-hp at 1800 rpm motor would produce 2.5 hp at 900 rpm.

There aren't any NEMA design standards for multi-speed motors. However, these motors are commonly available with Design B and Design C characteristics.

**Applications:** Uses for the constant-horsepower multi-speed motor are typified by cutting tool drives on machine tools. Constant-torque types are commonly used on feeders, mills, conveyors, and other applications where the torque load is constant at any speed. Variable-torque motors are applied to fans and centrifugal pumps where horsepower requirement varies as the square of the speed.

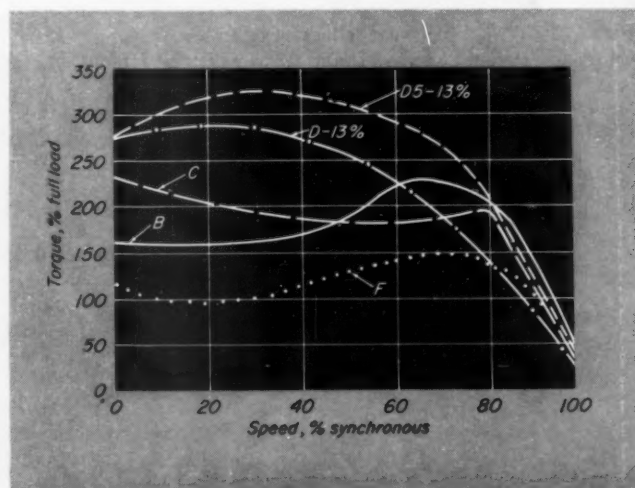


FIGURE 5. Speed-torque characteristics of NEMA Designs C, D, and F. Design B characteristic is included for comparison. Courtesy, Reliance Electric and Engineering Co.

## Squirrel-Cage Motor Control

There's really not much controlling to be done with squirrel-cage motors. They can, theoretically, be started by connecting them directly to the power lines. This is known as across-the-line starting and is generally used up to about 5 hp. For motors larger than this, the current surge is usually objectionable and some kind of reduced-voltage starter must be used. Reduced voltage starting may also be necessary to limit shock to the connected load.

There are four generally used methods of reduced voltage starting. These are:

1. Primary resistor starting—a fixed or variable resistor limits voltage and thus current during



acceleration and is then short circuited to apply full voltage.

2. Autotransformer starting—transformer taps supply reduced voltage for acceleration and full voltage for running.
3. Star-delta starting—special method of connecting motor windings to give 58% voltage and current, and 35% torque.
4. Part-winding starting—uses only one winding when motor winding is in two parts. Current reduced about 50%; torque is less than 50%. Used with dual voltage motors. Can be combined with resistor starting for more steps.

Usually, resistor starting is used for motors up to 20 hp. It generally costs less in this range and gives smoother acceleration than the autotransformer starter. In the 20 to 40 hp range, which type to use will depend upon motor characteristics. Those with low starting current can use the resistor starter. Above 40 hp,

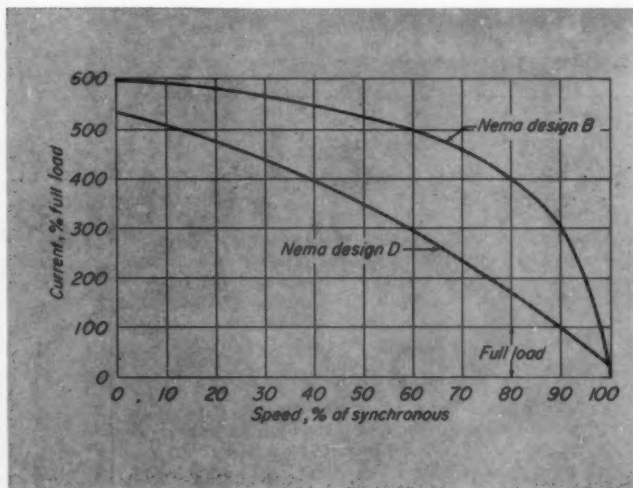


FIGURE 6. Current draw of Designs B and D compared.

the autotransformer is usually used because it limits line current draw to lower values.

**Stopping:** Of course, the power supply can be disconnected and a squirrel cage motor let drift to a stop. When quick, controlled stopping is needed, a brake can be used or the motor can be stopped by plugging. Plugging is simply switching the leads to apply voltage in such a way as to reverse rotation. The imminent stop must be sensed and power disconnected just before the stop to prevent reversal of the motor. Any 3-phase electrical motor can be reversed by interchanging any two of the three electrical leads.

**Speed control:** Since for a given supply frequency, these are essentially constant-speed motors, the only really good way to vary speed is by varying the supply frequency. This is quite expensive and rarely done.

## Electrical Ratings

All types of squirrel-cage motors are commonly available for voltages of 208, 220, 440, 550, and 2300. This last voltage is used only for motors of 40 hp or more. The others are used from ½ hp up. Small 400 cps motors commonly operate at voltages of 115 or less.

**Sizes:** Polyphase squirrel-cage motors are available with horsepower ratings from less than 0.001 hp to well over 1000 hp. Many of the small units are 400 cps, high-speed motors.

Physical dimensions of standard industrial squirrel-cage motors are defined in NEMA specifications. There can be considerable variations in the sizes of motors with the same hp rating. This depends on output speed and NEMA design. In general, the lower the output speed, the larger the motor, all other things being equal.

## Wound-Rotor Induction Motors

These motors are closely related to squirrel-cage motors. But, as their name indicates, the rotor is made up of wire windings rather than the bars used in squirrel-cage motors. If these wire windings were shorted in the same way the bars are shorted in a squirrel-cage motor, these motors would differ only in the construction; there would be no difference in performance. However, with the wound rotor, ends of the rotor windings are brought out to slip rings so resistance may be inserted in the rotor circuit externally, Fig. 7. Wound-rotor induction motors are often called slip ring motors for this reason.

By varying the amount of external resistance inserted in the rotor circuit, the speed-torque characteristics of a slip-ring motor may be varied over the range covered by the various NEMA designs of squirrel-cage motors. This permits combining the desirable starting and accelerating characteristics of one type with the desirable running characteristics of another. Fig. 8 shows how characteristics vary with different values of external resistance.

Speed may be easily varied with the slip-ring motor by varying rotor resistance. Range of about 2:1 is all that's recommended. When speed drops to less than half of synchronous speed, efficiency and power factor become very poor.

**Size and ratings:** These motors are available in sizes from a few horsepower to well over 2000 hp. Operating voltages run as high as 6600, with all normal voltages also included. Such high voltages are reserved for motors developing more than 500 hp.

## Synchronous Motors

These motors get their name from the fact that they run in absolute synchronism with the supply frequency. As with squirrel-cage and induction motors, supply frequency and the number of poles determines speed. Thus, for 60 cps, maximum speed is 3600 rpm. Table 1 lists speeds corresponding to three different supply frequencies for different numbers of poles.

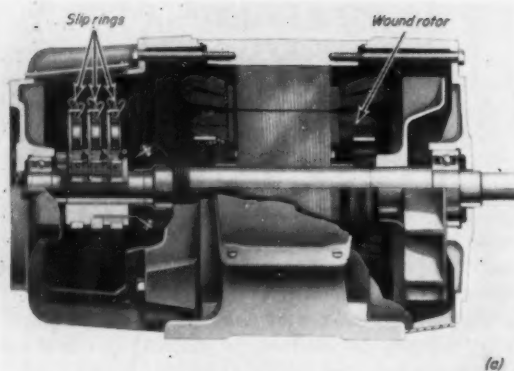
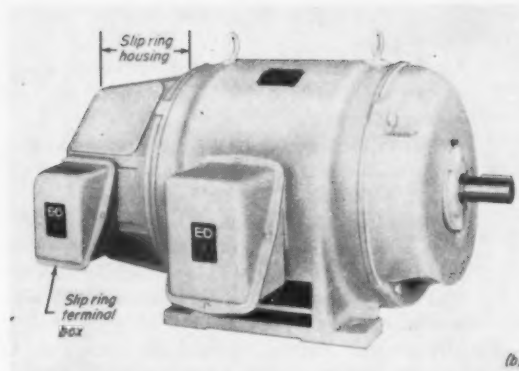


FIGURE 7. With wound-rotor induction motors, ends of the windings are brought out to slip rings, *a*. You can tell these motors because they have a slip ring enclosure on the end of the main motor enclosure and a terminal



box for making connections to the slip rings, *b*. Photo *a*, courtesy Westinghouse Corp.; photo *b*, courtesy Electro Dynamic Div., General Dynamics Corp.

#### AC MOTOR SELECTION *continued*

There are four types of polyphase synchronous motors: de-excited, synchronous-induction, reluctance, and hysteresis. There are fairly well defined power ranges into which these fall. Largest are de-excited. These are commonly made in sizes from about 50 hp up. Reluctance motors are made in sizes from

60 hp down to the very smallest. Next are the synchronous induction motors which range from 1 to 30 hp. Hysteresis synchronous motors are made in extremely small sizes and used as timing motors, and for similar applications such as recording instrument drives.

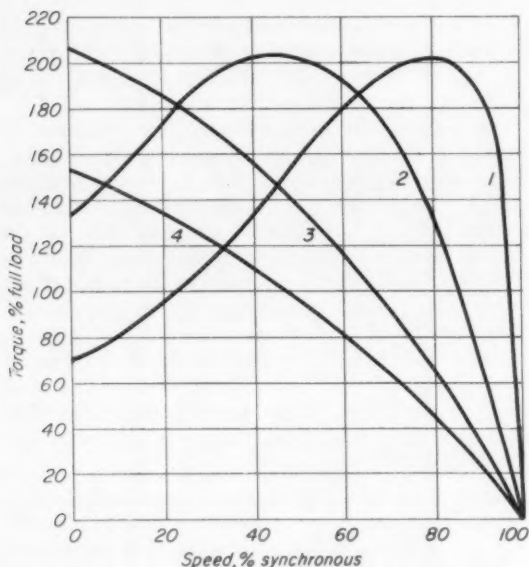


FIGURE 8. Characteristics of a wound-rotor motor for three different values of resistance in the rotor circuit and the shorted rotor. Curve 1 is for no external resistance in the circuit, or shorted rotor. This would be the motor characteristic curve if the windings were not brought out to slip rings. Curve 2 is for a small amount of external resistance. Note how the starting torque has increased. Curve 3 is for resistance which produces maximum starting torque. Curve 4 is for higher resistance than 3. This value of resistance lowers starting torque, but it is still higher than for Curves 1 and 2 and the current drawn is less than half what it would be with no resistance in the rotor circuit.

#### Power Factor

Power factor is the relationship of current and voltage to actual electrical power consumption. In ac circuits high currents can flow without doing any work. This happens if the current and voltage are out of phase (current peaks and voltage peaks occur at different times). The measure of how far out of phase voltage and current are is **power factor**. If power factor is 80% or 0.8, only this portion of the current and voltage is actually doing work. For example, with 230 v and 10 amp in an ac circuit, electrical power is the product of these and the power factor. Or,  $2300 \times 0.8 = 1840$  watts. If the power factor were 1 (current peaks and voltage peaks occur at the same time), only 8 amp would be needed for the same power.

Power companies don't like this situation because their wires have to carry 10 amp. And, they'll make an extra charge if the power factor is bad enough.

De-excited synchronous motors may be gotten with a power factor of 0.8 to balance the power factor of induction and squirrel cage motors. Power factors of the other types of synchronous motors are inductive, like the squirrel-cage and wound rotor. Voltage leads the current in induction motors and lags in de-excited synchronous motors.

Where power factor correction is not needed, synchronous motors with a 100% power factor are available and should be used to avoid a poor power factor situation. NEMA standard de-excited synchronous motors built to operate at 0.8 power factor have somewhat higher starting, pull-in and pull-out torques, Table 2, (Page 28).

(Continued on page 28)

easy, economical speed reduction

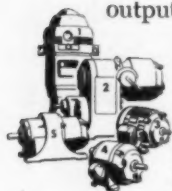
...with  
**U.S. quality**



## U.S. SHAFTMOUNT SYNCROGEAR

*reduces speeds... reduces design problems... reduces cost!*

U.S. Shaftmount Syncrogear offers not only the assurance of U.S. Motors quality standards, but many special advantages of design and construction as well. To assure precision, U.S. makes its own gears: *Microshaves* them to ideal profile, *hardens* them to exact toughness, then *hones* teeth after hardening for final superfinish that means quiet operation, lengthened life! U.S. Shaftmount Syncrogeareds are available for  $\frac{1}{4}$  to 40 h.p., output speeds 125 to 5 rpm.



**U.S. ELECTRICAL MOTORS INC.**  
P. O. Box 2058 • Los Angeles 54, California or Milford, Conn.

U.S. MAJOR MOTOR LINES INCLUDE:  
1. Vertical Solid & Hollowshaft, 2. Varidrive, 3. Totally-Enclosed,  
4. Uniclosed, 5. Syncrogear. Also, many other special motors.

Circle No. 61 on Reader Service Card

FREE  
SYNCROGEAR  
BROCHURE  
No. F-2003  
Color illustrated



# Polyphase Motor

Manufacturer	Squirrel-cage (hp)	Multi-speed Squirrel-cage (hp)	Wound Rotor (hp)	Synchronous (hp)
Air-Marine Motors, Inc., Amityville, L. I., N. Y.	1/300-1/2†			1/500-1/10†
Louis Allis Co., Milwaukee, Wis.	1/4-2500	1/4-125	1-800	1/4-25
Allis-Chalmers Mfg. Co., General Prod. Div., Milwaukee, Wis.	1/2-10,000	1-150	5-10,000	1/2-10,000
American Electronics, Inc., Los Angeles, Calif.	1/100-1/4*			
Balder Electric Co., St. Louis, Mo.	1/4-30	1/4-7 1/2		
Bodine Electric Co., Chicago, Ill.	1/50-1/4			1/2000-1/6
Bogue Electric Co., Paterson 3, N. J.	25-1000	25-1000	25-1000	1-1000
Brook Motor Corp., Chicago, Ill.	1-600		1-600	
Brown-Brockmeyer Co., Dayton, Ohio	1/8-100			
Century Electric Co., St. Louis, Mo.	1/4-400	1/4-125	2-400	
Columbia Electric Mfg. Co., Cleveland, Ohio				20-700
Continental Electric Co., Newark, N. J.	1-700	1-400	1-600	1-200
Delco Products Div., General Motors Corp., Dayton, Ohio	1/4-150	1/8-75		
Deerr Electric Corp., Cedarburg, Wis.	1/30-15	1/12-10		1/12-7 1/2
Eastern Air Devices, Inc., Dover, N. H.	1/1000-1/2	1/1000-1/2		1/1000-1/4
Eicor, Inc., Chicago, Ill.	1/10-5			
Electra Motors, Inc., Anaheim, Calif.	1/4-100	1/4-75	3/4-50	
Electric Indicator Co., Springdale, Conn.	1/350-1/3†			1/500-1/8†
Electric Machinery Mfg. Co., Minneapolis, Minn.	60-6000	60-3000	250-1500	25-15,000
Electric Products Co., Cleveland, Ohio	1-5000	1-500	1-5000	50-5000
Electric Specialty Co., Stamford, Conn.	1/4-40†	1/4-40†	1/4-30†	1/4-30†
Electro Dynamic Div., General Dynamics Corp., Bayonne, N. J.	1/2-800	1-600	3-700	
The Elliott Co. Div., Carrier Corp., Jeanette, Pa.	1/2-12,000	1/2-12,000	3-12,000	75-50,000
Emerson Electric Mfg. Co., St. Louis, Mo.	2-20			
Fairbanks, Morse & Co., Chicago, Ill.	1/2-10,000	1/2-10,000	1 1/2-10,000	1-10,000
Franklin Electric Co., Bluffton, Ind.	1/6-40			
General Controls Co., Glendale, Calif.	1/25, 1/12*			
General Electric Co., Schenectady, N. Y.	1/2-1000	1/2-125	3/4-500	FHP-5000
Globe Industries, Inc., Dayton, Ohio	1/250-1/5†			1/400-1/35†
The Hertner Electric Co., Cleveland, Ohio	.38-50*	1/1000-50*	1/200-10*	1/500-1*
Hoover Electric Co., Los Angeles, Calif.	1/2000-40*	1/8-10*	1/4-20*	1/10-10*
Howard Industries, Inc., Racine, Wis.	1/100-1/6			1/100-1/15

\* High-frequency motors † Power frequency (25, 50, 60 cps) and high frequency.



# Manufacturers Directory

Manufacturer	Squirrel-cage (hp)	Multi-speed Squirrel-cage (hp)	Wound Rotor (hp)	Synchronous (hp)
Howell Electric Motors Co., Detroit, Mich.	1/40-300	1/2-100	1/2-150	
Ideal Electric & Mfg. Co., Mansfield, Ohio	1-10,000	1/2-200	10-10,000	15-10,000
IMC Magnetics Corp., Westbury, L. I., N. Y.	sfhp-1 1/2†			1/200-1/3†
Imperial Electric Co., Akron, Ohio	1-200	1/4-125	1-150	
Jack & Heintz, Inc., Cleveland, Ohio	1/8-20†	1/8-20†		
Kearfott Div. of General Precision, Inc., Little Falls, N. J.				.00003-.0015*
Lamb Electric Co., Kent, Ohio		Special designs only		
Lear, Inc., Electro-Mechanical Div., Grand Rapids, Mich.	1/80-2			
Lima Electric Motor Co., Inc., Lima, Ohio	1/2-150	1/2-75		
The Lincoln Electric Co. Cleveland, Ohio	1/2-40			
Marathon Electric Mfg. Corp., Wausau, Wis.	1/20-3500	1/20-3500	75-3500	20-5000
Marble Electric Corp., Gladstone, Mich.	1-100		1-100	
The Moore Co., Kansas City, Mo.	1/2-100	1/2-100		
National Pneumatic Co., Inc., Holtzer-Cabot Div., Boston, Mass.	.00006-1	1/100-1	1/2000-1/12	.00003-1
Newman Electric Motors, Inc., Newark, N. J.	1-600	1-600	1-600	
Northwestern Electric Co., Chicago, Ill.	1-50		1/2-50	
Peerless Electric Co., Div. H. K. Porter Co., Inc., Warren, Ohio	1/3-30	1/3-30		
Pesco Products Div., Borg-Warner Corp., Bedford, Ohio	1/125-20			
Reliance Electric & Engineering Co., Cleveland, Ohio	1/8-2000	1/8-150	1/2-400	1/8-7 1/2
Reuland Electric Co., Alhambra, Calif.	1/20-40	1/8-20	1/2-30	
Robbins & Myers, Inc., Springfield, Ohio	1/50-200			
Rotating Components, Inc., Brooklyn, N. Y.	1/2000-1/4†	1/2000-1/4†		1/2000-1/20†
Shelby Electric, Inc., Shelbyville, Ind.	1/2-15	1/2-15		
Skurka-Langdon Engineering Co., Los Angeles, Calif.	1/1000-7 1/2*	1/4-5*		1/1000-3/4*
Small Motors Inc., Chicago, Ill.	1/20-1/8			
A. O. Smith Corp., Tipp City, Ohio	1/3-800	1/3-800	1-800	-800
Sterling Electric Motors, Inc., Los Angeles, Calif.	1/4-200	1/2-125		
U. S. Electrical Motors, Inc., Los Angeles, Calif.	1/4-500†	1/4-50†		
Wagner Electric Corp., St. Louis, Mo.	1/6-1000	1/3-100	2-200	
B. A. Wesche Electric Co., Cincinnati, Ohio	1/8-40			
Westinghouse Electric Corp., Pittsburgh, Pa.	1-1000	1-1000	1-700	1-450

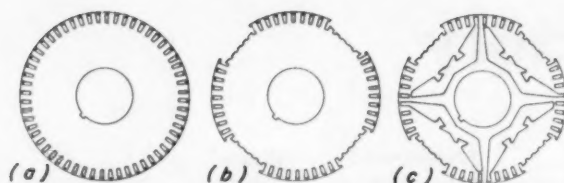


FIGURE 9. Squirrel-cage, *a*, reluctance, *b*, and synchronous-induction, *c*, motor rotors compared. Cutting away of a portion of the rotor causes the reluctance motor to operate at synchronous speed. The synchronous-induction motor rotor is cut away in the same manner. Internal flux guiding paths improve efficiency. Courtesy, The Louis Allis Co.

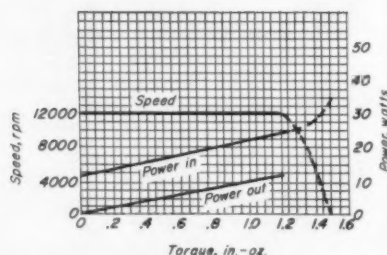


FIGURE 10. Speed-torque and power curves for the small (10 watt output = 0.0134 hp) hysteresis synchronous motor shown. This is a 115 v, 400 cps unit. Courtesy, Globe Industries, Inc.

#### AC MOTORS continued

Dc-excited synchronous motors are somewhat more complicated than squirrel-cage motors since they require dc applied to the rotor. This means a dc supply is needed and that slip rings and brushes are used. In its favor are somewhat higher efficiency and rugged construction. Efficiency at light loads is even better, related to squirrel-cage and induction motors, than at full load.

Since a dc-excited synchronous motor runs at full speed or not at all, a squirrel-cage type starting winding is part of the rotor. This winding is used to start

Table I—Synchronous Motor Speeds

No. of Poles	Speeds		
	25 cps	50 cps	60 cps
2	1500	3000	3600
4	750	1500	3000
6	500	1000	1200
8	375	750	900
10	300	600	720
12	250	500	600
14	214	428	514
16	188	375	450
18	166	333	400
20	150	300	360
22	136	273	327
24	125	250	300
26	115	231	277
28	107	214	257
30	100	200	240
32	94	188	225
36	83	167	200
40	75	150	180

Table II—Synchronous Motor Torques

Speed (rpm)	Power factor	Hp	Torque*		
			Starting	Pull-in	Pull-out
1800	1.0	To 200	110	110	150
514-1200	1.0	To 200	110	110	175
514-1800	1.0	250-500	110	110	150
514-1800	1.0	600 up	85	85	150
1800	0.8	To 150	125	125	200
514-1200	0.8	To 150	125	125	250
514-1800	0.8	200-500	125	125	200
514-1800	0.8	600 up	100	100	200

\*Torques are expressed as a percentage of full-load torque.

the motor and bring it as close as possible to synchronous speed. The other rotor winding is then energized with dc and the motor pulls into synchronism. The starting winding has no effect when the motor is running at synchronous speed because the rotating magnetic field of the stator does not cut its conductors. But, any instantaneous change in speed due to a sudden change in load will cause a torque to be exerted by the starting winding. This torque always opposes the speed change. The starting winding is also called a damper winding for this reason.

The reluctance motor is related to the squirrel-cage motor as shown in Fig. 9. The cutting away of the rotor to produce salient poles causes it to run in synchronism. Efficiency and power factor of these motors are generally poorer than the squirrel-cage or dc-excited synchronous motors. In small sizes these factors are not particularly important as compared to the low first cost of this motor.

Synchronous induction motors are like the reluctance motor in that basic rotor design resembles the squirrel-cage rotor with portions cut away. But, the synchronous induction motor rotor has internal flux guiding paths to provide low flux resistance between the salient poles, Fig. 9c. This improves efficiency, power factor, and current draw. Also, syn-

ronous induction motors are smaller than the reluctance motor of equal horsepower.

Synchronous induction and reluctance motors are used to drive alternators where exact input speed is necessary to provide constant-output frequency and in drives where exact synchronization of speeds of shafts driven by separate motors is necessary.

The hysteresis synchronous motor uses a perfectly smooth rotor and develops constant speed from zero to full-load torque, Fig. 10. Efficiencies of these units are low, but in the power ranges for which they are made, this is usually of little importance.

**Sizes and ratings:** Horsepower ratings range from 1/2000 to 50,000. Output speeds are from about 72 rpm to 24,000 rpm. These speeds are for frequencies from 25 to 400 cps. The higher speeds are, of course, for 400 cps motors. Limit for 60 cps is 3600 rpm.

### Mechanical Variations

Most commonly used types of electric motors are available with different types of mountings and enclosures to fit them to a variety of applications.



Motors may be foot, face, or flange mounted, Fig. 11. NEMA has type designations which are commonly used to designate these variations. Type C is face-mounted; Type D is flange-mounted; Types P and PH are for vertical mounting on flange or face and have solid or hollow shafts. The dc-excited synchronous motor in large sizes is commonly supplied for engine mounting, Fig. 11e.

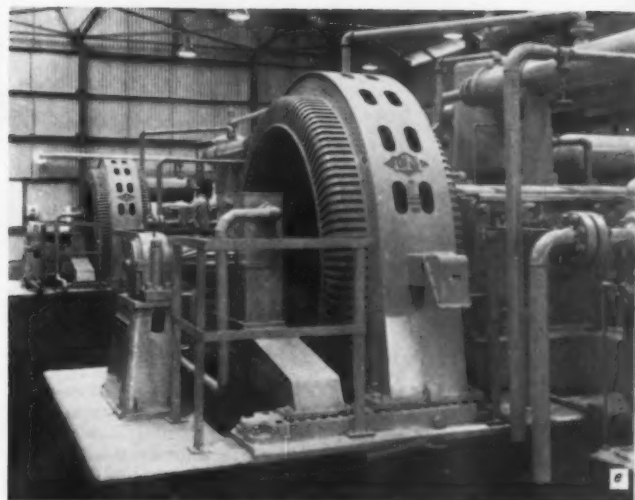
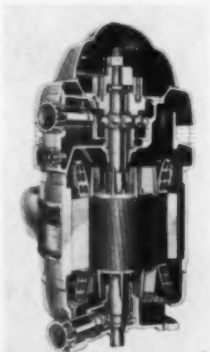
Horizontal motors for foot mounting may be mounted on floor, wall, or ceiling as long as the shaft is kept horizontal. Motors for vertical mounting are special designs with bearings to withstand the vertical thrust due to the weight of the rotor.

**Enclosures:** There's real variety in the types of enclosures available. NEMA lists 19 kinds. They are either open or closed. Brief descriptions are in Table III. Fig. 12 shows some of these.

**Special motors:** In addition to the different mechanical variations so far discussed, there are definite-purpose motors as defined by NEMA and motors built with some special feature for a customer. Definite-purpose motors are departures from standard



**FIGURE 11. Motor mounting variations.** Conventional foot mounting for an integral hp motor, *a*, courtesy Franklin Electric Co. NEMA Type C face mount, *b*, courtesy Sterling Electric Motors, Inc. NEMA Type D flange mount, *c*, courtesy U. S. Electrical Motors Inc. Vertical hollow-shaft motor, *d*, photo courtesy U. S. Electrical Motors Inc. The 2250 hp synchronous motor, *e*, used to drive a reciprocating compressor is an engine type. This means that the manufacturer supplies it less the shaft and bearings. Rotor is mounted on the compressor shaft



and the stator is mounted on soleplates set in concrete. A portion of the motor is below floor level. Photo, courtesy Electric Machinery Mfg. Co.

## AC MOTOR SELECTION *continued*

constructions, specially-designed for specific applications. These are:

1. Hermetic refrigeration condensing unit motors. (Squirrel-cage stator and rotor without shaft, end shields or bearings for building into hermetically-sealed refrigeration condensing units.)
2. Fractional-hp motors for belt driven refrigeration compressors. (Squirrel-cage)
3. Fractional-hp motors for jet pumps. (Squirrel-cage)
4. Fractional-hp motors for shaft-mounted fans and blowers. (Squirrel-cage,  $\frac{1}{8}$  hp and larger)

5. Fractional-hp motors for gasoline dispensing pumps. (Squirrel-cage)
6. Fractional-hp motors for coolant pumps. (Squirrel-cage)
7. Submersible motors for deep-well pumps. (Squirrel-cage)
8. Elevator motors. (Squirrel-cage, multi-speed squirrel-cage, and wound-rotor)
9. Crane motors. (Wound-rotor)
10. Shell type motors (Rotor and stator without shafts, endshields, bearings, or conventional frame for building into machinery)

These types are standard production with many motor manufacturers as are certain of the other special types shown in Fig. 13 and 14. ▼▼▼

## Some motor enclosure variations

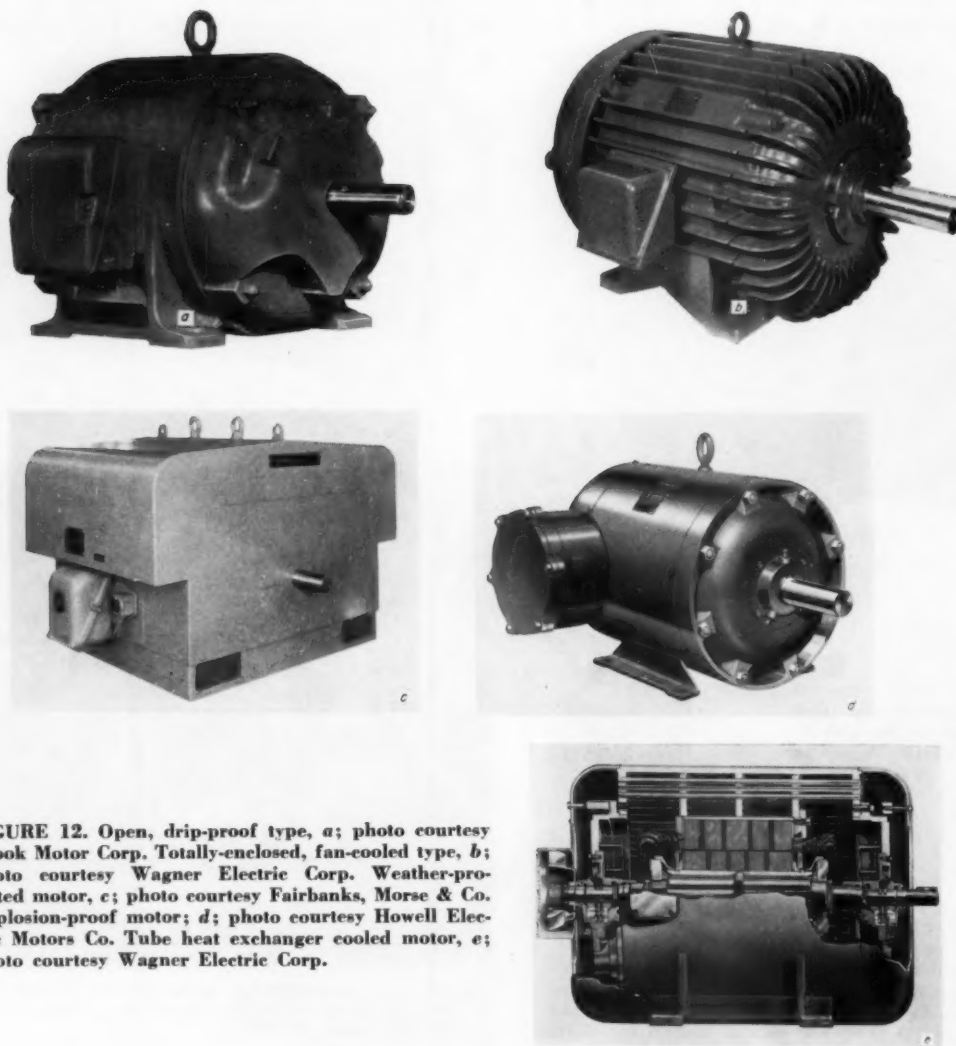


FIGURE 12. Open, drip-proof type, a; photo courtesy Brook Motor Corp. Totally-enclosed, fan-cooled type, b; photo courtesy Wagner Electric Corp. Weather-protected motor, c; photo courtesy Fairbanks, Morse & Co. Explosion-proof motor; d; photo courtesy Howell Electric Motors Co. Tube heat exchanger cooled motor, e; photo courtesy Wagner Electric Corp.





FIGURE 13. Special electric motors. Rotor and stator for building into a hermetically-sealed compressor unit, a; photo courtesy Delco Products Div., General Motors



Corp. Force-ventilated motor, b, for high duty cycles has small cooling motor which continues to run when the main motor is stalled; photo by Imperial Electric Co.

### Table III—Enclosure Variations

#### OPEN TYPES

1. **DRIP-PROOF**—Drops or particles falling at angles of 15 deg or less from vertical cannot enter the motor through the ventilating openings.
2. **SPLASH-PROOF**—Drops or particles coming toward the motor at angles of 100 deg or less from vertical cannot enter the motor ventilating openings either directly or by running along a surface of the motor.
3. **GUARDED**—All openings giving access to live or rotating parts are constructed or screened in such a way that contact with these parts is impossible.
4. **SEMI-GUARDED**—Part of the openings, usually those in the top half like the guarded motor.
5. **DRIP-PROOF, FULLY-GUARDED**—Combines 1 and 3.
6. **EXTERNALLY-VENTILATED**—Separate motor-driven blower mounted on the motor for cooling. May be combined with any of the previous 5.
7. **PIPE-VENTILATED**—Pipes may be connected to the ventilating openings for ventilation by an integral or separate blower.
8. **WEATHER-PROTECTED, TYPE 1**—Ventilating openings constructed to minimize entrance of rain, snow, or other airborne particles to the electric parts, and to prevent passage of a  $\frac{3}{4}$  in. diam rod.
9. **WEATHER-PROTECTED, TYPE 2**—In addition to Type 1 provisions, high-velocity air and air-borne particles blown into the machine can be discharged without entering internal passages leading to the electrical parts.

#### TOTALLY-ENCLOSED TYPES

1. **NON-VENTILATED**—Not equipped for cooling by means external to the enclosure.
2. **FAN-COOLED**—Cooled by integral fans or fans outside the enclosure.
3. **EXPLOSION-PROOF**—Designed to withstand explosion within the enclosure of a specified gas or vapor, and to prevent ignition of the gas or vapor outside the enclosure by flame or sparks coming from within the enclosure.
4. **DUST-IGNITION-PROOF**—Enclosure designed to exclude ignitable amounts of dust or amounts which might affect performance. Also, will not let arcs, sparks, or heat inside the enclosure ignite exterior accumulation or airborne dust in the vicinity.
5. **WATER-PROOF**—Will exclude water applied in a stream from a hose. Leakage may occur around the shaft if water cannot enter oil reservoir and automatically drains from the motor.
6. **PIPE-VENTILATED**—Only openings to the enclosure are for connection of ventilating ducts. Air circulating means may be integral or separate.
7. **WATER-COOLED**—Cooled by circulating water. Water or water conductors contact the machine parts.
8. **WATER-AIR-COOLED**—Has water-cooled heat exchanger to cool ventilating air and fan or fans for circulating ventilating air.
9. **AIR-TO-AIR-COOLED**—Internal air cooled by a heat exchanger cooled by external air. Separate fan or fans for circulating both internal and external air.
10. **FAN-COOLED GUARDED**—All openings to the external, integral fan designed to prevent accidental contact with the fan. Openings shall not permit passage of  $\frac{1}{2}$ -in. diam rod except where distance from guard to fan is more than 4 in. they shall not permit passage of  $\frac{3}{4}$ -in. diam rod.

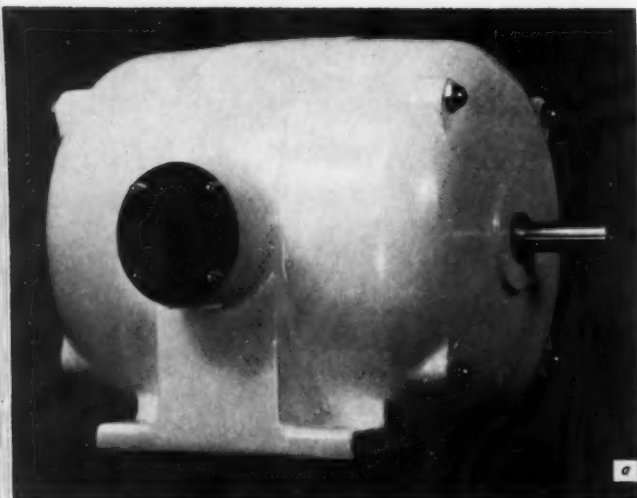


FIGURE 14. Sanitary motor, *a*, has smooth, crevice free exterior and is completely enclosed; photo courtesy Electra Motors, Inc. The face-mounted motor, *b*, was



specially designed to permit adjustment of tension on the blade of a metal-cutting bandsaw; photo courtesy The Peerless Electric Co.

### Acknowledgement

Co-operation of the following companies in providing information for use in this article is acknowledged with thanks.

Air-Marine Motors, Inc. ....Amityville, N. Y.  
Louis Allis Co. ....Milwaukee 1, Wis.  
Allis-Chalmers Mfg. Co. ....Milwaukee 1, Wis.  
American Electronics, Inc. ....Los Angeles 17, Calif.

Barber-Coleman Co. ....Rockford, Ill.  
Bodine Electric Co. ....Chicago, Ill.  
Bogue Electric Mfg. Co. ....Paterson 3, N. J.  
Brook Motor Corp. ....Chicago 45, Ill.  
Brown-Brockmeyer Co. ....Dayton 1, Ohio

Century Electric Co. ....St. Louis 3, Mo.  
Columbia Electric Mfg. Co. ....Cleveland, Ohio

Delco Products Div.,  
General Motors Corp. ....Dayton 1, Ohio  
Doerr Electric Corp. ....Cedarburg, Wis.

Eicor, Inc. ....Chicago 39, Ill.  
Electra Motors, Inc. ....Anaheim, Calif.  
Electric Indicator Co. ....Springdale, Conn.  
Electric Machinery Mfg. Co. ....Minneapolis 13, Minn.  
Electric Products Co. ....Cleveland 12, Ohio  
Electro Dynamic Div.,  
General Dynamics Corp. ....Bayonne, N. J.  
Elliott Co., Div. Carrier Corp. ....Jeannette, Pa.  
Emerson Electric Mfg. Co. ....St. Louis 21, Mo.

Fairbanks, Morse & Co. ....Chicago 5, Ill.  
Franklin Electric Co. ....Bluffton, Ind.

General Controls Co. ....Glendale 1, Calif.  
General Electric Co. ....Schenectady, N. Y.  
Globe Industries, Inc. ....Dayton 4, Ohio

Hansen Mfg. Co., Inc. ....Princeton 10, Ind.  
The Hertner Electric Co. ....Cleveland, Ohio

Hoover Electric Co. ....Los Angeles 25, Calif.  
Howell Electric Motors Co. ....Detroit 35, Mich.

IMC Magnetics Corp. ....Westbury, L. I., N. Y.  
Imperial Electric Co. ....Akron, Ohio

Lamb Electric Co. ....Kent, Ohio  
Lear Inc., Electro-Mechanical Div. Grand Rapids, Mich.  
Leland Ohio Electric Co. ....Dayton, Ohio  
Lima Electric Motor Co., Inc. ....Lima, Ohio  
The Lincoln Electric Co. ....Cleveland 17, Ohio

Marble Electric Corp. ....Gladstone, Mich.  
The Master Electric Div.,  
Reliance Electric & Engineering Co. ....Dayton 1, Ohio

Newman Electric Motors, Inc. ....Newark, N. J.  
Northwestern Electric Co. ....Chicago, Ill.

Peerless Electric Co.,  
Div. H. K. Porter Co., Inc. ....Warren, Ohio

Redmond Co., Inc. ....Owosso, Mich.  
Reliance Electric & Engineering Co. Cleveland 17, Ohio  
Reuland Electric Co. ....Alhambra, Calif.  
Robbins & Myers, Inc. ....Springfield 99, Ohio  
Rotating Components, Inc. ....Brooklyn 22, N. Y.

Shelby Electric Inc. ....Shelbyville, Ind.  
Small Motors Inc. ....Chicago, Ill.  
Sterling Electric Motors, Inc. ....Los Angeles 22, Calif.

U. S. Electrical Motors, Inc. ....Los Angeles 54, Calif.  
Universal Electric Corp. ....E. Owosso, Mich.  
Uppco, Inc. ....Chicago 7, Ill.

Wagner Electric Corp. ....St. Louis 14, Mo.  
B. A. Wesche Electric Co. ....Cincinnati 36, Ohio  
Westinghouse Electric Corp. ....Pittsburgh 30, Pa.

DESIGN  
**IDEAS**  
FROM THE FIELD

## New ball-galaxy transmission does high-torque work efficiently

A BRAND-NEW type of variable-speed transmission—the ball galaxy—is being used on a line of centrifuges made by Genisco, Inc., Los Angeles. The unique geometry involved in this transmission was discovered a few years ago by Prof. William S. Rouverol of the University of California.

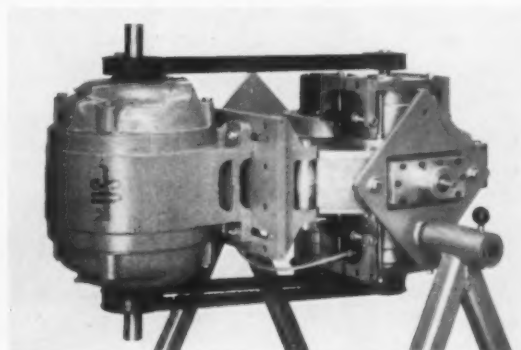
This transmission—said to have an efficiency of 80%—has a cluster or galaxy of 8 hardened-steel balls arranged in a circle within a rotatable cage. The balls project slightly beyond either surface of the cage.

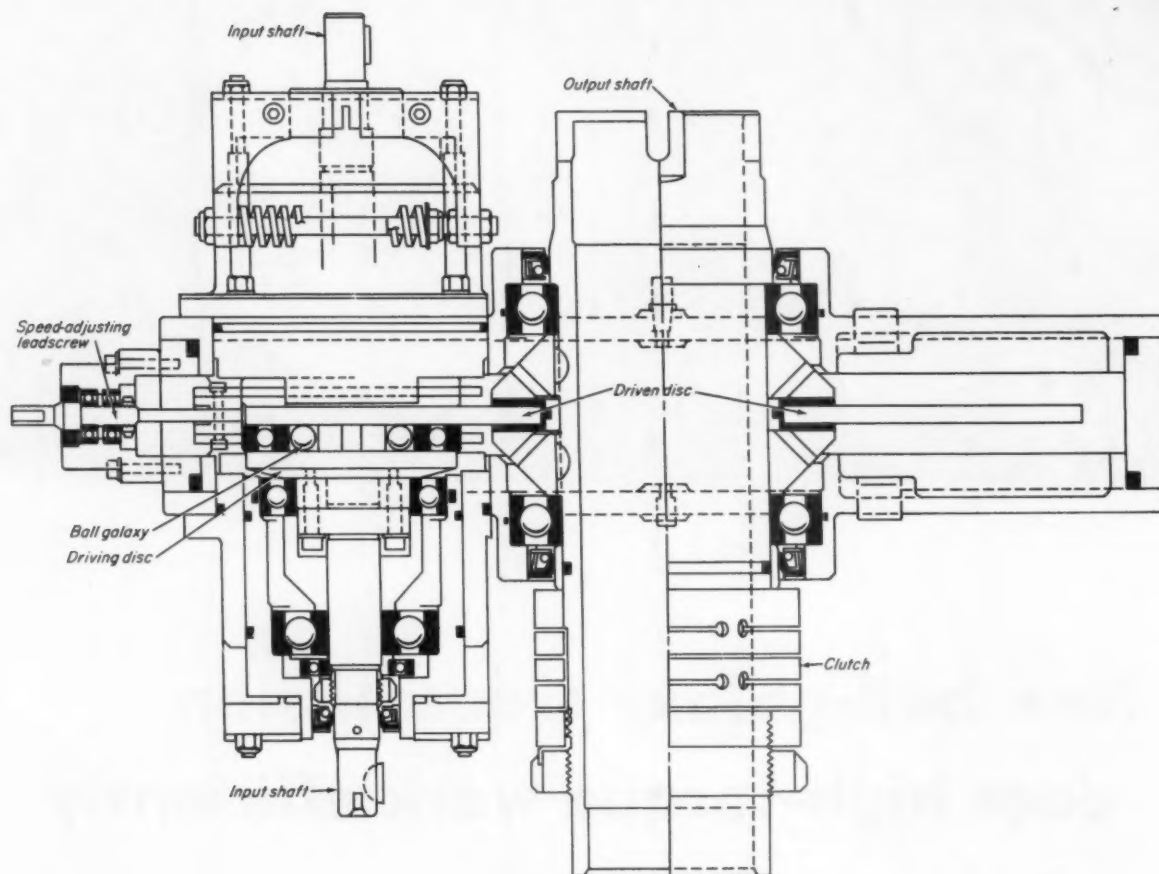
The galaxy of balls is pressed between a driving disk and a driven disk, with its axis of rotation in the plane of the axes of the disks. The disks also are hardened steel. The driving disk turns the balls in the galaxy, and the balls transmit this force to the driven disk. Each ball, which can rotate freely in any direction, creates driving torque throughout a rather complex orbit.

The cage rotates at the average angular velocity of the two disks. Each ball moves at constant speed in a circular orbit about the center of the cage,

and each ball follows a continuously-changing track different from the individual tracks of the other balls. Each ball also has a superimposed spinning motion that permits it to roll without slipping on the faces of the disks.

Driving torque is a function of the amount of preload pressures applied to the balls and disks by





#### BALL-GALAXY TRANSMISSION *continued*

spring assemblies. Final output torque is controlled by a slip clutch which couples the output disk to the output shaft. This built-in torque-limiter clutch protects the transmission from damage by abuse or high-inertia conditions.

With this type of transmission, higher pressures can be accommodated with a resulting output torque greater than might be expected.

The ratio of input speed to output speed is determined by the ratio of the distances from the axis of the galaxy to the axes of the driving and driven disks. By shifting the galaxy laterally, this ratio, and therefore the output speed, may be changed. The maximum input/output speed ratio in the Genisco transmission is 6.315:1. Speeds are changed

by moving the galaxy assembly with a leadscrew turned by a handwheel.

The input disk's drive shaft is driven by an electric motor through a toothed belt drive. Maximum input speed is limited to about 5400 rpm.

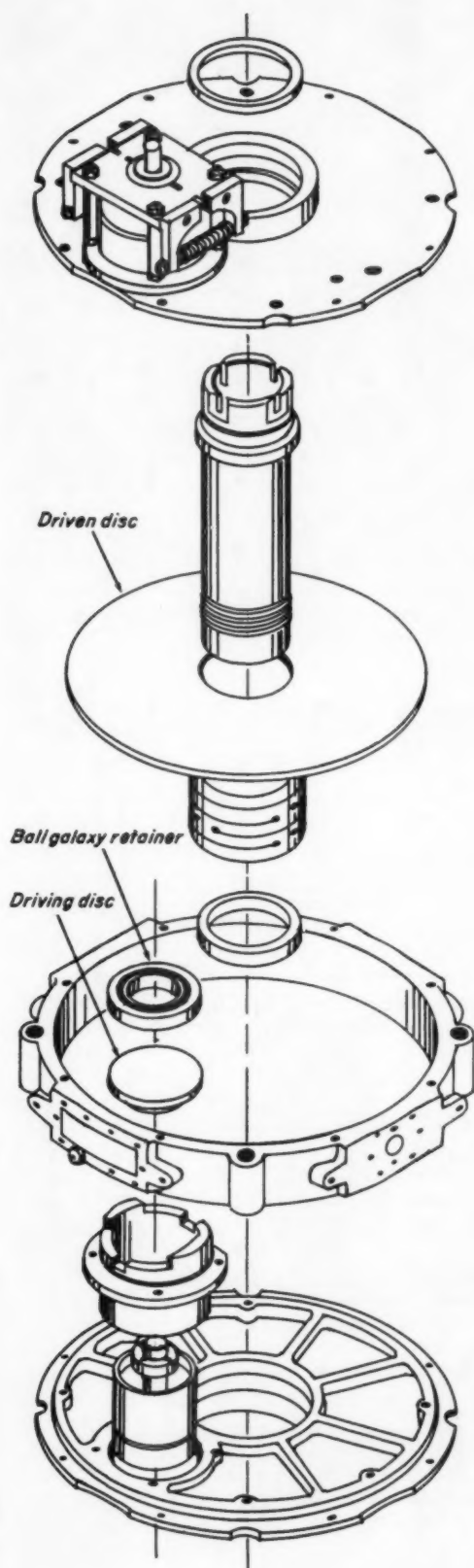
Since the output disk is coupled directly to the output shaft, there is virtually no wow or flutter throughout the useful speed range. In fact, when output torque requirements are constant, wow and flutter caused by internal conditions will be less than .01%.

Alignment is extremely important. With ideal alignment and adjustment, there is no mechanical bind or ball skidding, and the surfaces of the balls and disks will improve rather than deteriorate. However, if the axis of the galaxy is offset from the common center line between the disks, the balls must travel



## IDEAS

continued

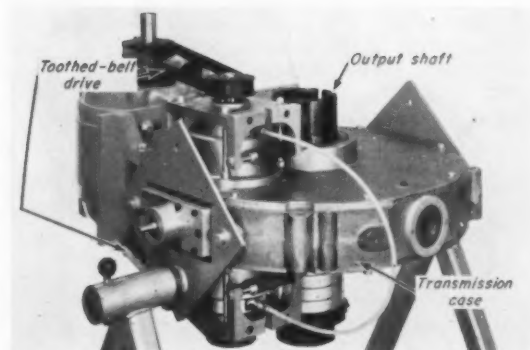


faster (hence farther) during one half of the orbit than the other. This creates an opposition which greatly reduces efficiency.

Genisco gets angular compliance which allows a small amount of discrepancy by using a slightly resilient TFE compound in bushings around each ball. The TFE bushings are partially swaged around the balls for increased bearing area. In addition to having a low coefficient of friction, the bushings transfer heat away from critical areas.

A circulating oil supply in the transmission case dissipates heat, inhibits rust accumulation, and filters out foreign particles, as well as providing lubrication.

▲▲▲



**EXPLODED VIEW** of ball-galaxy transmission (left) shows only the major components used in the completely assembled unit (above). Notice that the case, shafts, and disks as designed so that close alignment may be maintained when the transmission is assembled. This is extremely important for efficient operation.

## Gear train eliminates valve noise

A GEARED drive assembly runs like clockwork to index a control valve in a domestic cabinet model water softener made by Bruner Corp., Div. of Hagan Chemicals & Controls, Inc., Milwaukee.

This softener, the fully-automatic Empress 15, has adjustable softening capacity (3000 to 15,000 grains). It softens water up to 40 grains of hardness per gallon.

It takes 12 gallons of water to recharge the softener. The recharge control valve starts the 1-hour process in the middle of the night when most households are asleep. However, the valve is designed to make water available to all lines during recharge should it be needed.

The control valve is a motor-driven helical spool valve that rotates smoothly and slowly, eliminating water knock or hammer that might possibly disturb light sleepers.

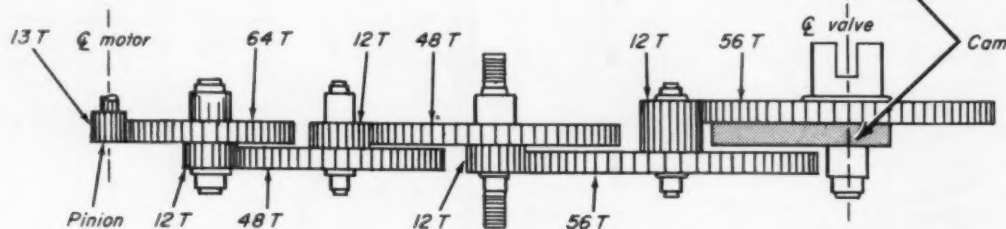
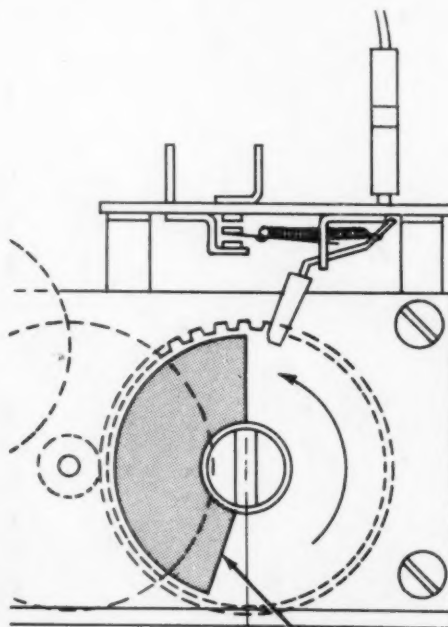
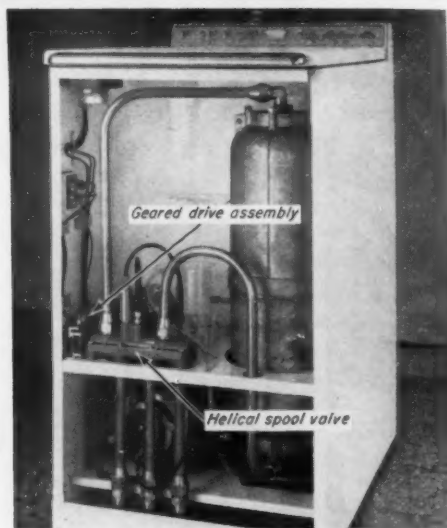
The recharge control is a clock-timer normally set to recharge from 2:30 to 3:30 a.m. At 2:30 a.m., the timer starts the motor of the control valve drive assembly. The motor, driving through a gear train, turns the helical spool valve. After the valve turns 180° to its recharge position, a cam on the shaft driving the valve operates a switch to stop the motor. This cam/switch makes sure valve rotation is stopped precisely, at the proper position.

An hour later, after recharging, the timer again starts the motor. Again the cam-operated switch stops the motor when the valve completes a 180° turn back to service position.

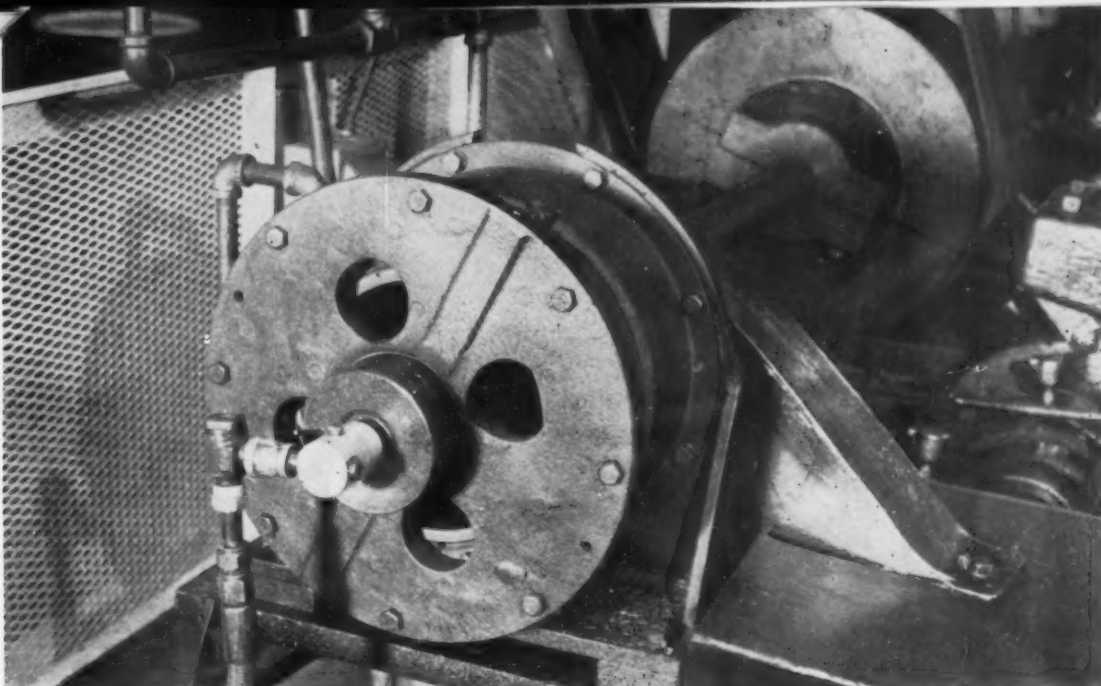
The motor, rated at .0025 hp, develops .075 lb-in. torque at its full load speed of 2300 rpm. The motor drives a train of six spur gears, and the total ratio of the train is 3300:1. Therefore, it takes almost

half a minute to rotate the valve from service to recharge and return.

The gears are made of sintered iron, coined to close tolerances so they mesh quietly. They are impregnated with oil and never have to be relubricated. The gear train includes a pinion on the motor, four cluster gears, and the gear that drives the switch-operating cam and the spool valve. ▲▲▲



OUTPUT GEAR of train which turns valve has cam which actuates motor switch.



Photos, courtesy Fawick Airflex Div., Fawick Corp.

## Air clutches pay 500% dividend

AIR-OPERATED CLUTCHES and brakes have eliminated costly machine jamming and tool damage at Frantz Manufacturing Co., Sterling, Ill., with an original investment of \$500 saving the company an average of \$2500 a year in time, labor, and production costs.

The company makes butt hinges, using butt hinge curling machines to roll, form, broach, countersink, and drill coiled steel stock. Before modernizing these machines, Frantz ran into operating deficiencies which often proved costly.

The old single-station manual controls consisted of a foot brake and a long-handled clutch. They were not always handy to the operator. The time it took to stop the machine after an operating malfunction often was enough to cause jamming, damaged parts, and broken tools.

To improve the machines, Frantz included additional mechanical operations that required increased shaft speeds and more accurate power transmission control. This was done with air clutches and brakes mounted on the 6 ft belt-driven main drive shaft. Pushbutton controls were mounted at convenient points around the machines.

With instant-acting, smooth power transmission through these drum type clutches and brakes, plus remote control, the operator now makes setups more quickly, operates his machine more efficiently, and turns out better products. ▲▲▲



HINGE CURLING machine used to be operated with a foot brake and a long-handled clutch. This setup wasn't convenient and caused a lot of costly trouble. Today the machine is equipped with an air clutch, shown here, which has ended breakdowns, speeded up setup, and saved considerable money.

## IDEAS

continued



Photo, data courtesy T. B. Wood's Sons Co.

# Compact V-belts reduce bearing overhang

REDESIGN from a conventional V-belt drive to a new compact drive has reduced bearing overhang by  $1\frac{1}{4}$  in. on the *Stump Gobbler* tractor attachment made by Myers-Sherman Co., Streator, Ill.

The *Stump Gobbler* mounts on the rear of any standard tractor, its telescopic drive shaft driven by the tractor's power takeoff at 535 rpm. The shaft drives a set of 16 rotating saw blades through multiple V-belts. The drive ratio of 1.77 speeds up the blades to 944 rpm. Total horsepower transmitted is between 30 and 42 hp.

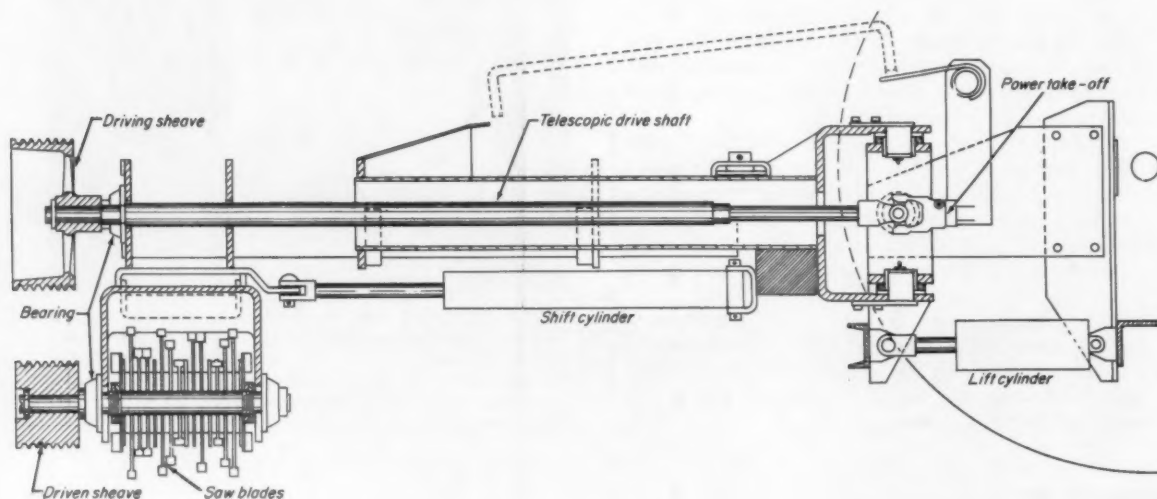
The *Gobbler* can remove a 2 ft stump in 10 to 15 minutes by chewing it up with its special saw blades. The cutting teeth bite off a section 2 in. deep and 12 in. wide with every pass, pour-

ing chips and sawdust out of its discharge opening in a continuous stream. It can move up and down, in or out, and from side to side.

As originally designed, the drive had 7-groove sheaves for B-section belts, which are  $21/32$  in. wide and  $13/32$  in. deep. Outside diameter of the driving sheave was 13.9 in., that of the driven, 4.8 in.

The compact drive has 7 3V-section belts, which are  $3/8$  in. wide by  $5/16$  in. deep. Belt length is 63 in., center-to-center distance, 19.2 in. The outside diameter of the new driving sheave is 10.6 in. However, because the drive ratio was reduced, the outside diameter of the driven sheave is now 6 in.

▲▲▲







# **BEARINGS**

**DESIGN / APPLICATION**

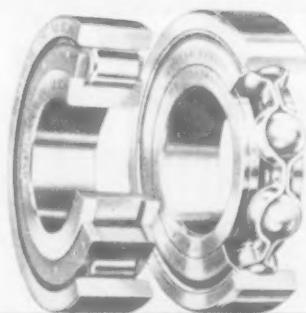
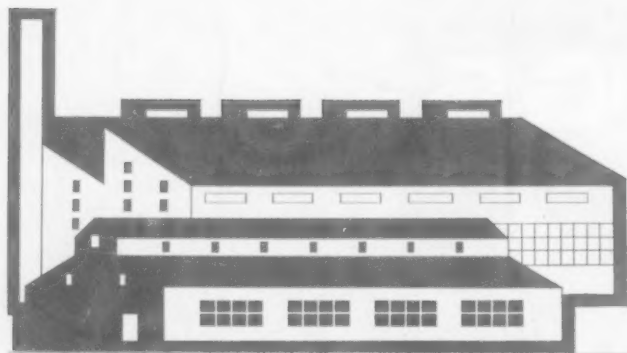


**REGULAR MONTHLY  
SECTION OF IDEAS  
AND DEVELOPMENTS**



**POWER  
TRANSMISSION  
DESIGN**

**YOUR BUSINESS IS IN THE BALANCE . . .** and bearing failures can work against you. That's why it's important to specify New Departure ball bearings and Hyatt roller bearings for the machinery in your plant. They provide significant performance reliability, the kind of worry-free, trouble-free service that helps to cut costs and keep maintenance to a minimum. Together N/D and Hyatt are the world's largest manufacturer of bearings. With nearly 30,000 original equipment customers, they supply bearings for virtually every type of industrial equipment in use today. These high quality, durable bearings are readily available to you through the national network of N/D-Hyatt Industrial Bearings Distributors . . . who are backed up by United Motors Service bearings warehouses across the country. So when you replace bearings, be sure you get the best fast. Specify New Departure and Hyatt from your Industrial Bearings Distributor.



New Departure and Hyatt bearings are supplied through . . . U-M-S

**HYATT** **NEW DEPARTURE**  
Circle No. 60 on Reader Service Card **POWER TRANSMISSION DESIGN**

A selection guide for . . .

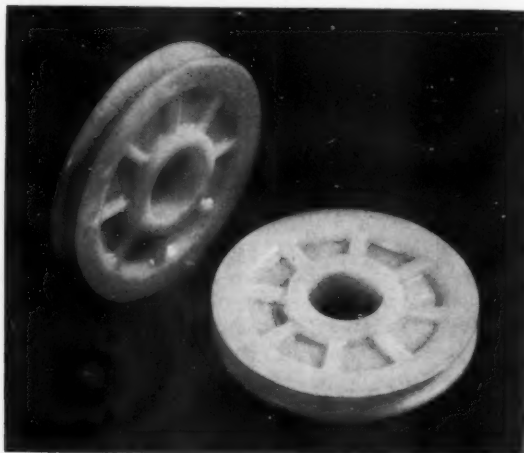
# Unlubricated plastic bearings

By R. E. HARMON, engineer,  
special products department, Garlock, Inc.

BEARINGS THAT WILL OPERATE DRY can be a boon to designers and consumers. Such bearings haven't been used more because proper component materials and sufficient design data wasn't available. This article is to help rectify the latter.

A bearing's job is to position relatively moving parts and reduce friction. The ideal bearing would do this without wear or frictional heat. But most materials with high enough load-carrying capacity to make a practical bearing also have high wear rates and relatively high frictional resistance. One remedy for this is a lubricant—oil, grease, graphite, talc, etc.—which separates the sliding surfaces of the bearing. As long as the lubricant is a continuous film, the sliding takes place within the lubricant layer and not at the moving parts. The more nearly perfect the lubricant layer, the less important it is what the sliding parts are made of, and the lower the friction and wear.

There are various ways to maintain the lubricant film. There are centralized and automatic lubrication systems. There are self-lubricated bearings, in which the lubricant is supplied from within one of the relatively moving parts. Examples are solid graphite bearings and porous or indented metal bearings filled with liquid or solid lubricant. These have been classed



**PARKING BRAKE PULLEY** of molded Delrin is a real improvement on the stamped metal pulleys it replaced. The one-piece molding is inexpensive, provides a good bearing surface for the stranded wire cable it guides, and a good bearing surface for rotation.

## Editor's Note

*Lacking adequate engineering data, designers have avoided using unlubricated plastic bearings, even in applications where they would have been outstanding. By presenting here—for the first time—a selection guide for evaluating suitability of plastic materials now available for dry bearings, we hope to be of some help in changing this.*

*Although we feel this article is a major contribution toward understanding characteristics of these materials, which should lead to their fullest use, it's necessary to emphasize that there's still much to be learned. The author, Richard Harmon, cautions that this material is only a preliminary guide to determine basic feasibility of a design. Confirming tests must still be made. The proof of the bearing is in the running.*

*The selection table has been extrapolated from various existing data by Harmon, drawing on his 20 years experience with elastomers and plastics with government and private industry. Others, he points out, may interpret some of the data differently.*

as *fit and forget* bearings, because the supply of lubricant is often sufficient to last the working life of the mechanism. But the lubricant degrades with time, so that friction and wear increase, making these bearings only partially satisfactory in many applications. Then, there are lubricated-service applications where the lubricant film may be broken momentarily at certain points in the cycle, again resulting in wear and friction.

But there are cases where a dry or unlubricated bearing would be welcome. Also, there are some jobs where it's better if there is no lubricant, because it may cause contamination. Food, paper, and textile machines are examples of this. Another group of applications where the unlubricated bearing really fits well is where the lubricant can't do its job because of environment, such as dampness, high humidity, high or low temperature, and atmosphere from vacuum to dirt contamination. Natural limitations of petroleum-base lubricants make their use impossible under some or all of these conditions.

In spite of all the advantages of the greaseless bearings, it's only within the last 10 to 15 years that plastic materials have been developed to make them practical. Much experimental work has been necessary to determine the capabilities of these materials, and much more must still be done.

It's only very recently that sufficient data has be-

## UNLUBRICATED PLASTIC BEARINGS *continued*

come available to permit first-approximation predictions of dry bearing performance. These enable us to discard obviously unsatisfactory choices, and indicate where confirming tests might prove worthwhile.

### Unlubricated Bearing Materials

Plastic materials now being used for dry bearings are nylon, Delrin and Teflon. They are used alone or in composite bearings in the following ways at present:

Type 1: Unmodified resins

1a: Nylon and Delrin

1b: Teflon

Type 2: Filled resins

2a: Nylon and Delrin

2b: Teflon

Type 3: Teflon mixtures with rigid backing

Type 4: Teflon fabric with metal or other backing

Type 5: Teflon-lead impregnated porous bronze, with steel backing.

Types 3, 4 and 5 are fairly new, but Types 1 and 2 have been used for ten years or so. Undoubtedly there will be improvements within all of these types, and new types may be developed.

This article will discuss the properties of these materials which affect their use as dry bearings. But, it's worth mentioning that there are many applications where addition of a lubricant can improve their performance by providing a supporting film, transferring heat, protecting mating surfaces from corrosion, etc. The materials are definitely oil and grease resistant, and are used with lubricants in many applications.

#### Type 1—Unmodified Resins

The three plastic materials in their natural or unmodified form have certain common physical properties which must be given particular consideration in bearing applications (unless cross-section is extremely thin). Most important of these properties are: (1) high coefficient of thermal expansion, (2) low heat conductivity, (3) low compressive strength, or load-carrying capacity.

Coefficients of thermal expansion are in the range of  $5$  to  $10 \times 10^{-5}$  in./in./deg F for Type 1 and 2 bearings. This is about ten times that of metal, and means that diametral clearances in the range of  $0.005$ - $0.015$  in./in. diam are needed between shaft and bearing to prevent shaft seizure due to expansion in full journal types. Thin walls and split journals to allow circumferential expansion without ID reduction will reduce thermal expansion problems. Otherwise these bearings can only be used where considerable shaft play can be allowed. This is one of the first points to consider when selecting a dry bearing material.

Modulus of elasticity for dry bearing plastics is one-tenth to one-twentieth that of common sleeve bearing metals. Also it decreases fairly fast in the normal operating temperature range.

Nylon is also subject to expansion due to absorption

of moisture. There can be considerable variation in this property among the 20 or 30 types of nylon available. A new Type 11 nylon developed in Europe and now being introduced is not affected as much by humidity changes and moisture absorption as the older types. Delrin is hardly affected by moisture.

Because of low thermal conductivity of Type 1 plastic bearings, heat generated at the rubbing surface can be conducted away only by the shaft, for all practical purposes. This limits the rubbing velocity of the unmodified plastic bearings. Low thermal conductivity also reduces load-carrying capacity, because the materials soften as their temperature increases. Teflon with higher temperature resistance is less susceptible to this softening than the thermoplastics, nylon or Delrin.

Load-carrying capacity of nylon and Delrin is very good in the unmodified state. Teflon, however, will cold-flow or relax under load, unless in a very thin film. In a film less than  $0.0007$  in. thick, it will support  $50,000$  psi at low sliding velocities. Generally, sliding velocities for unmodified Teflon should not exceed  $10$  fpm for any appreciable length of time. This rule may be bent if: the load is very light; water, oil or forced air cooling is used; or life required is very short.

Upper temperature limits for continuous service of Type 1 bearings are: Nylon,  $250$  F; Delrin,  $180$  F; and Teflon,  $500$  F. A further limitation is that shaft temperature must not exceed  $175$  F for nylon or Delrin. These values are not ambient temperatures; they are actual temperatures of the parts.

Another important—and unique—property of Teflon and Delrin is that their dynamic and static coefficients of friction are equal or nearly so. Thus, there can be no slip-stick operation with them. There is little slip-stick with nylon.

#### Type 2—Filled Resins

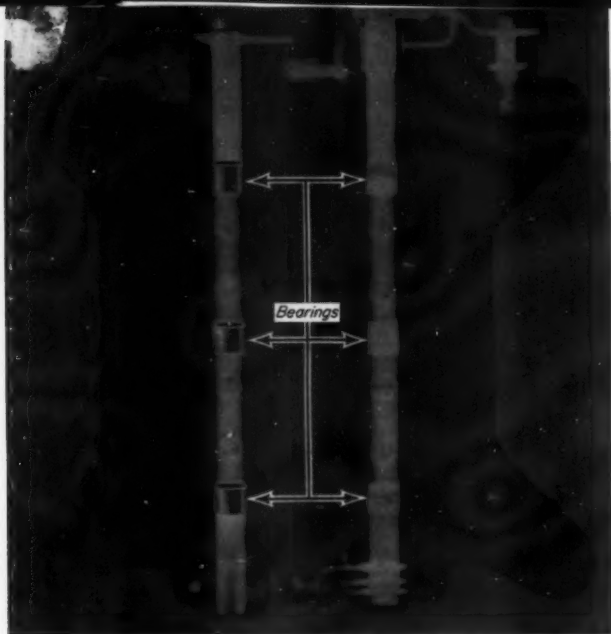
Earliest filled plastic bearing materials were nylon and Teflon mixed with glass fibers. Asbestos, molybdenum disulfide, carbon, bronze, iron oxide, and other materials are also being used, alone or in combination. Fillers increase load-carrying capacity, wear resistance, and maximum allowable operating temperature. Wear resistance of a filled Teflon bearing may be  $500$  times as great as that of an unmodified bearing. Thermal expansion of a filled Teflon bearing may be  $50$ - $70\%$  less than its unmodified version.

One illustration of the vast improvement made in Teflon by a carbon filling is a railroad passenger car truck slide bearing. Here, there was little noticeable wear after  $120,000$  miles of service. The next best material tested failed after  $10,000$  miles.

Practically all fillers increase the coefficient of friction. However, in nearly all applications, the power required to overcome the frictional resistance is insignificant compared to that available, and this is more than paid for by the advantages gained.

Filled plastic bearings generally have a constant wear curve after the original wear-in lets maximum area support the load.





**THROTTLE SHAFT BEARINGS** on a four-barrel carburetor are Type 1 unmodified resin. Bearings used in this application have proverbially been unlubricated since engine heat, dirt, and soot would soon result in a gummy mess.

### Type 3—Filled Teflon With Rigid Backing

These bearings are made by impregnating wire screen, perforated metal, and similar materials with a filled Teflon, or by adhering them to metal. Net result of this construction is to further improve desirable properties while reducing the problems of thermal expansion, heat conductivity, and compressive strength compared to Types 1 and 2. Most Type 3 bearings use Teflon, but nylon-clad bearings are also available.

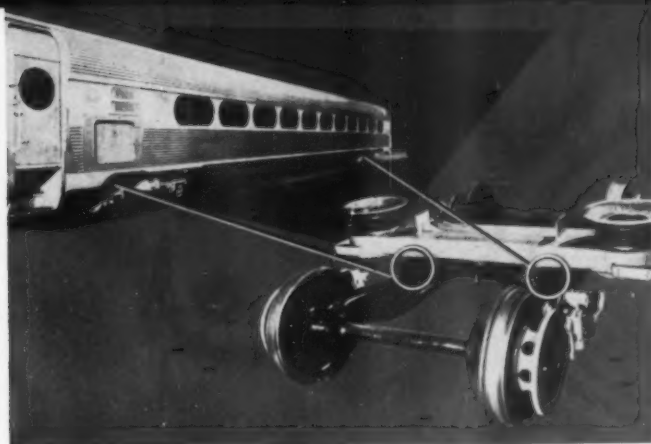
### Type 4—Woven Teflon With Backing

With woven Teflon, stretching the fibers overcomes low load-carrying capacity of the unmodified material. Voids in the fabric and the thin layer generally used eliminate the thermal expansion problem when there's a metal backing. Thermal conductivity, however, is still low. This limits these bearings to low-speed applications. By using other fibers, such as cotton or glass, with the Teflon fibers, properties of the bearings can be varied considerably to fit many applications. Load-carrying capacity is outstanding, compared to preceding types.

One limiting factor for these bearings results from their construction. Phenolic adhesives and/or plastics are used to fasten them to the backing. As temperature goes up, two things happen: the adhesive's holding ability weakens, and the Teflon fibers try to return to their unstretched state. This limits sliding velocities to about 60 fpm.

Wear rates for these bearings are  $6 \times 10^{-6}$  in./hr. Required installation clearances are low.

Tests of these bearings in automotive suspension and steering ball joints have been quite successful. Rod end bearings of this type also appear to be successful in the aircraft industry.



**CARBON-FILLED TEFLON** railway car truck slide bearings show little wear after 120,000 miles of operation. Next best material tried wore out in 10,000 miles.

### Type 5—Impregnated Porous Bronze

This bearing is made up of a steel backing strip, a thin porous bronze middle layer (made by sintering spherical bronze powder onto a steel backing) impregnated with a mixture of Teflon and lead powder, and an overlay up to 0.001 in. of the Teflon-lead mixture.

The steel backing provides structural strength to permit high loads and a lasting, tight, interference fit. The impregnated bronze layer conducts heat away from the rubbing surface and acts as a reservoir for the Teflon-lead mixture, to assure a constant supply at the rubbing surface. The overlay applies a thin coating of the mixture to the mating surface to smooth over irregularities and make a low-friction surface of it. This bearing will give long service, even after the overlay has been removed by initial bedding-in.

The Type 5 bearing overcomes many of the limitations of Types 1 through 4. It has the lowest thermal expansion and highest heat conductivity. Load-carrying ability is of the same order as for woven types. It will operate at high speeds and has been used successfully at up to 8000 rpm. Bedding-in wear is fairly rapid—spread over the first 50 to 100 hours—followed by very low wear. Typical wear rate is  $4 \times 10^{-7}$  in./hr. Recommended installation clearance is from 0.0001 to 0.003 in., regardless of diameter.

### Estimating Dry Bearing Life

These are the factors that affect service life of dry bearings—and to a large extent, any bearing. (Most do not show up in the standard  $PV = K$  relationship):

1. Sliding velocity
2. Maximum ambient temperature
3. Heat sink size
4. Acceptable frictional resistance
5. Load per unit area
6. How load is applied
7. Initial and continuing alignment accuracy
8. Surrounding atmosphere
9. Finish and material of mating surface
10. Tolerable wear rate and clearance

**Heat:** The first four items in this list are involved with the operating temperature of a bearing. There's

## UNLUBRICATED PLASTIC BEARINGS *continued*

no pat answer to just how much they affect service life, but maximum temperature limits are, of course, known.

Temperatures above 250 F and below -50 F make selection of a Teflon bearing mandatory. Types 2, 3, and 5 would give best service. Temperatures slightly above 500 F have been handled by Type 5 bearings.

It's known that sliding velocity affects wear life of filled Teflon (Type 2b), to the extent that in the familiar formula  $PV = K$ ,  $V$  should probably be closer to  $V^2$ . Because the metal-reinforced types have far better heat conductivity, the exponential value of their velocity approaches 1. It's interesting to note that unfilled Teflon (Type 1b) has extremely good wear resistance at cryogenic temperatures.

As far as sliding velocity goes, in dry operation only Type 5 bearings can operate at high velocities for 1000 hr or more of continuous service. This is because of this type's ability to conduct heat into the housing.

All other types are limited to short-time service at speeds above 200 fpm.

**Load:** How the nature of the load—i.e., unidirectional, rotating, or oscillating—affects life of Type 5 bearings is shown in Table I. Whether or not the other types are affected in the same way is not known at present. Whereas oscillation is the most difficult condition for lubricated bearings, it's easiest for Type 5.

Magnitude of the load has very positive effects on life, of course. Therefore, misalignment will reduce life, since it results in higher unit loading. Nevertheless, misalignment must be tolerated in some cases. Bearing types with the largest clearances and best conformability or flow characteristics will last longest where misalignment exists. Comparative ability to function well with misalignment present is one of the factors evaluated in Table II.

**Atmosphere:** Abrasive dirt in any bearing will reduce its life. Dry bearings are no exception. Almost all plastic bearings will operate longer in dirty atmospheres if there is no initial lubrication. Also, they tend to embed dirt better than metal bearings, so their life is not shortened by dirt to the same degree.

Corrosion resistance is the amount and kind of metal filler and backing, or the adhesive used in the fabrication of the bearing, with composite bearings. All of the plastics themselves have good chemical resistance; the best is Teflon, followed by Delrin and nylon.

**Finish:** Best service life is obtained when mating surfaces have a 20-microinch rms finish or better.

Rougher surfaces mill away the bearing and reduce life. Hard shafts, to 55 Rockwell C, also increase service life.

**Tolerable wear:** This is usually a function of the application rather than the bearing. For the Type 5 bearing, it's assumed that 0.005 in. is the maximum allowable wear in most applications.

All of the preceding factors influence wear rate, of course. But there is no reliable design information for all bearing types based on identical testing conditions for dry operation, in which comparable service life is related to other factors, such as load or velocity.

So, the best we can do in selecting a bearing material is to consider each type in the operating conditions of a particular application, eliminate the obviously unsuitable types, and then make the compromises generally required in the use of any engineering material.

Some of our values in this analysis will undoubtedly be questioned, and adjustments may be required, but we believe the general approach is sound, since it considers factors which cannot readily be included in a single equation such as  $PV = K$ .

## Shaft Deflection

A possible starting point for the designer is to determine the maximum tolerable shaft deflection in a particular application. The shaft deflection will be the sum of the wear and the initial clearance provided to accommodate the thermal expansion of the plastic.

Although it's impossible to predict wear rates accurately at this time, the following working figures, based on available literature, may be useful. These values are the very best reported and will permit calculations of the least shaft deflection for a given type. (If wear is greater, shaft deflection is greater.)

Types 1a, 2a—About  $1.25 \times 10^{-4}$  in./hr at 25 fpm with a 1-in. shaft. Can be considerably less with initial lubrication.

Type 2b—About  $1.6 \times 10^{-5}$  in./hr at 100 fpm and 80 psi for 1-in. shaft and 1-in.-long bearing.

Type 4— $6 \times 10^{-6}$  in./hr at 25 fpm and 1150 psi.

Type 5— $4 \times 10^{-7}$  in./hr at 25 fpm and 2000 psi.

*continued on page 46*

TABLE I—Nature of Load vs. Load-Velocity Constants for Type 5 Plastic Bearings

Nature of Load	Velocity Constants*			
	Mild Steel†		Hard Steel	
	1000 hr	10,000 hr	1000 hr	10,000 hr
Unidirectional	16,000	12,000	25,000	19,000
Rotating	25,000	19,000	30,000	24,000
Oscillating				
shaft fixed				
load	30,000	23,000	33,000	24,000

\*  $K$  in  $PV = K$  †Also applies to cast iron, austenitic stainless steel, anodized aluminum, and mild steel electroplated with lead, cadmium, or nickel.

TABLE II—Selection Ratings for Dry Bearings (Types Listed on Page 42)

	Rating*					
	A	B	C	D	E	F
Low shaft clearance	5	4	3	2	1b	1a
High sliding velocity	5	3	2	4	1a	1b
Wide temperature range	5	3	2b	4	1b	1a-2a
Load carrying ability	4	5	3	2	1a	1b
Corrosion resistance	1b	2b	3	4	1a-2a	5
Misalignment tolerance	1	2	3	4	5	—
High PV	4-5	4-5	3	2	1a	1b

\*A is best, B next best, etc.



Bearing at left has 1.75" bore, while tandem bearing in main illustration has 17.0" bore. Yet both are standard, cataloged items.

## Over 400 Cataloged Thrust Bearings to fit your every need . . .

When you need a thrust bearing, no matter how special, Rollway is ready with the know-how and the precision machinery to design and produce it for you.

Our engineers will gladly consult with you regarding any standard or special-purpose types you need. No cost. No obligation. Rollway Bearing Co., Inc., Syracuse, N. Y.

**Complete line of Radial and Thrust Cylindrical Roller Bearings**



# ROLLWAY<sup>®</sup>

## BEARINGS

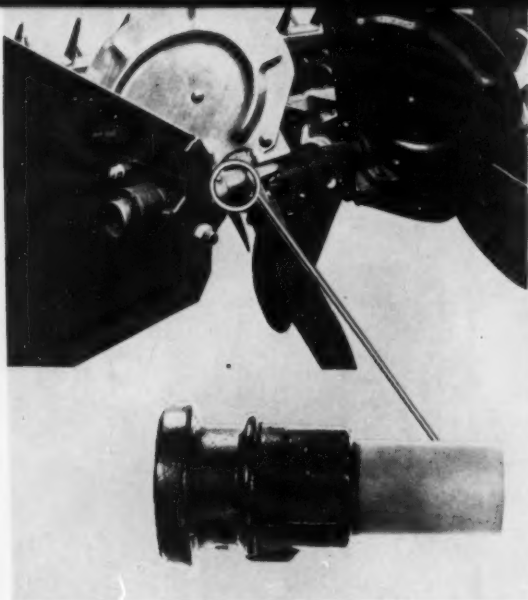
### ENGINEERING OFFICES:

Syracuse • Boston • Chicago • Detroit • Toronto  
Pittsburgh • Cleveland • Seattle • Houston  
Philadelphia • Los Angeles • San Francisco

### Select from 7 ROLLWAY Standard Types

designed, tested and  
ready for production with  
load capacities to  
4,800,000 pounds.

Ask for Catalog  
PT-659.



**RAPID FAILURE** of metal sleeve bearings used on this manure spreader was caused by acids. Filled Teflon bearings last the life of the spreader with no attention. Metal bearings had to be greased every two days.

#### UNLUBRICATED PLASTIC BEARINGS *continued*

As you can see, there are considerable gaps in actual observed wear rates for the various types of dry bearings, which make shaft deflection a sensitive criterion.

The following figures are suggested initial clearances for the various types; added to the wear they give shaft deflection.

- Type 1a—0.004-0.015 in./in. diameter
- Type 1b—0.004-0.006 in./in.
- Type 2a—0.004-0.015 in./in.
- Type 2b—0.004-0.006 in./in.
- Type 3 —0.004-0.005 in./in.
- Type 4 —0.002-0.005 in./in.
- Type 5 —0.0001-0.003 in. (any diameter)

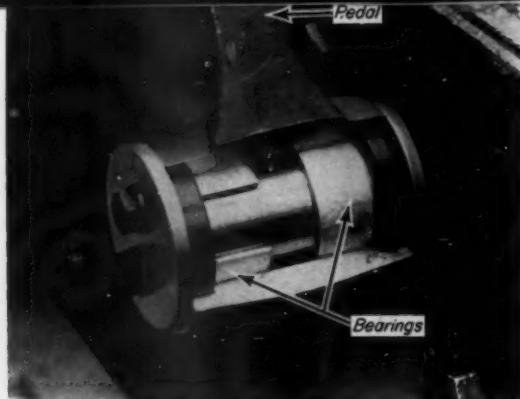
### PV Relationships

As mentioned in the discussion of factors contributing to heating, the conventional  $PV = K$  relationship used with other types of bearings doesn't quite fit with dry bearings. Velocity has pretty definite limits beyond which even a modified equation can't be used. We'd like to repeat that while  $PV$  is not a constant, we're assuming it is for quick analysis in the following examples:

Load-velocity relationship for dry operation of Delrin is  $PV = 7600/V^{0.20}$ , or  $PV = 1600$  for a quick approximation.

For Zytel 101 nylon,  $PV = 40,000/V^{0.47}$ , or  $PV = 2300$  for a quick approximation. This data is based on 5 million operating cycles with a 1-in.-diam steel shaft.

For unfilled Teflon,  $PV = 1000$ , with speed limited to 10 fpm. For filled Teflon,  $PV = 8000$  is reasonable, with speed limited to 200 fpm. Adding metal reinforcement to filled Teflon would increase the  $PV$  value to 10,000 from a practical design viewpoint.



**IMPREGNATED POROUS BRONZE, Type 5, bearings** are used successfully on the clutch and brake pedal shafts of some trucks and buses. Need for lubrication is eliminated.

For Type 4 bearings, published curves covering velocities to 60 fpm yield  $PV$  values from 20,000 to 44,000, for 1000-hr life. Since these were obtained with initial lubrication, they should be revised downward for completely dry operation.

For Type 5 bearings, recently reported  $PV$  values range from 12,000 to 33,000 for 1000-hr continuous dry service. There appears to be no limiting velocity for these. It's generally accepted that hydrodynamic air lubrication sets in at 5000 rpm.

Again, it should be remembered that lubrication, if it can be tolerated, will improve performance tremendously.

### Selection

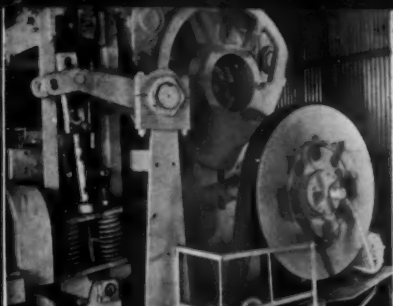
Except for cost, all of the major factors involved in selecting the proper dry plastic bearing material have been covered. They have been summarized in Table II, which provides a summary of the relative performance of the five types. By comparing job requirements with Table II, it should be possible to quickly determine the most likely materials for further investigation.

Cost hasn't been considered, since it doesn't affect the serviceability of a bearing. Generally, though, Delrin and nylon bearings in Type 1 and 2 are the least costly for fairly large volume requirements, as they can be injection molded. Costs of other types vary so widely with design that it's not possible to generalize. ▲▲▲

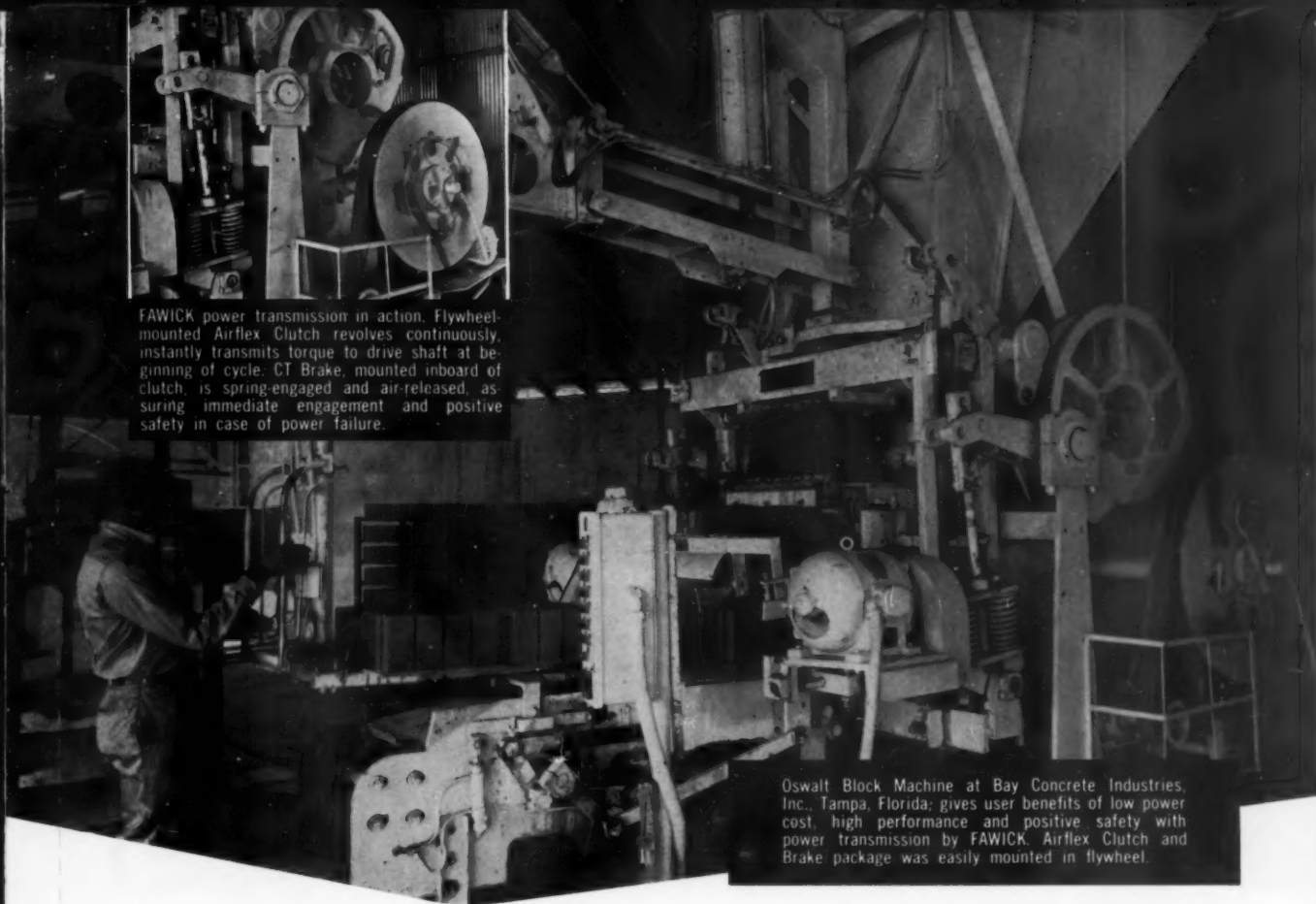
### Bibliography

- "Engineering Facts on Teflon Bearings No. 6," Polychemicals Dept., E. I. duPont de Nemours & Co., Inc.
- "Thin Films of Polytetrafluoroethylene Resin as Lubricants and Preservative Coatings for Metals," by V. C. Fitzsimmons and W. A. Zisman, Industrial and Engineering Chemistry, May 1958.
- "Engineering Facts on Teflon Fabric Bearings," Textile Fibers Dept., E. I. du Pont de Nemours & Co. Inc.
- "Design Data for Bearings of Nylon, Acetal, and TFE Fluorocarbon Resins," by G. S. Hudson and L. H. Gillespie, AISI Paper, Fall Meeting, 1958.
- "Du Pont Design Digest—Bearings of Delrin Acetal Resin," Polychemicals Dept., E. I. du Pont de Nemours & Co. Inc.
- "Glacier Dry Bearings", Automotive Engineer, May 1960—Great Britain.





FAWICK power transmission in action. Flywheel-mounted Airflex Clutch revolves continuously, instantly transmits torque to drive shaft at beginning of cycle. CT Brake, mounted inboard of clutch, is spring-engaged and air-released, assuring immediate engagement and positive safety in case of power failure.



Oswalt Block Machine at Bay Concrete Industries, Inc., Tampa, Florida; gives user benefits of low power cost, high performance and positive safety with power transmission by FAWICK Airflex Clutch and Brake package was easily mounted in flywheel.

## Fawick Airflex cuts power requirements ... keeps machine output at peak

Low operating power costs with no sacrifice of output capacity is an economy you can build into any cyclic machine with FAWICK Airflex Clutches and Brakes.

Oswalt Engineering Service Corporation, Forest Park, Illinois, is passing this benefit on to users of their newest Model 60 concrete block making machine. Previously, cycling was accomplished with a drive motor and brake only. To start each cycle, the motor had to build up enough torque to put almost two tons of machine components into motion. The motor stopped at the end of each cycle, and inertia was lost. This frequent build-up and let-down resulted in high power costs plus excessive motor wear.

The modernized power transmission system uses a CB Airflex Clutch and CT heavy-duty Brake mounted in combination with a non-stop flywheel. Inertia is never lost at the end of a cycle because the flywheel and clutch keep revolving, storing up energy for the next cycle. The operator merely pushes a button to engage the clutch with the main drive shaft for instantaneous torque transmission. Block production is increased due to fast starts and stops with simplified controls. The drive motor lasts longer and, running

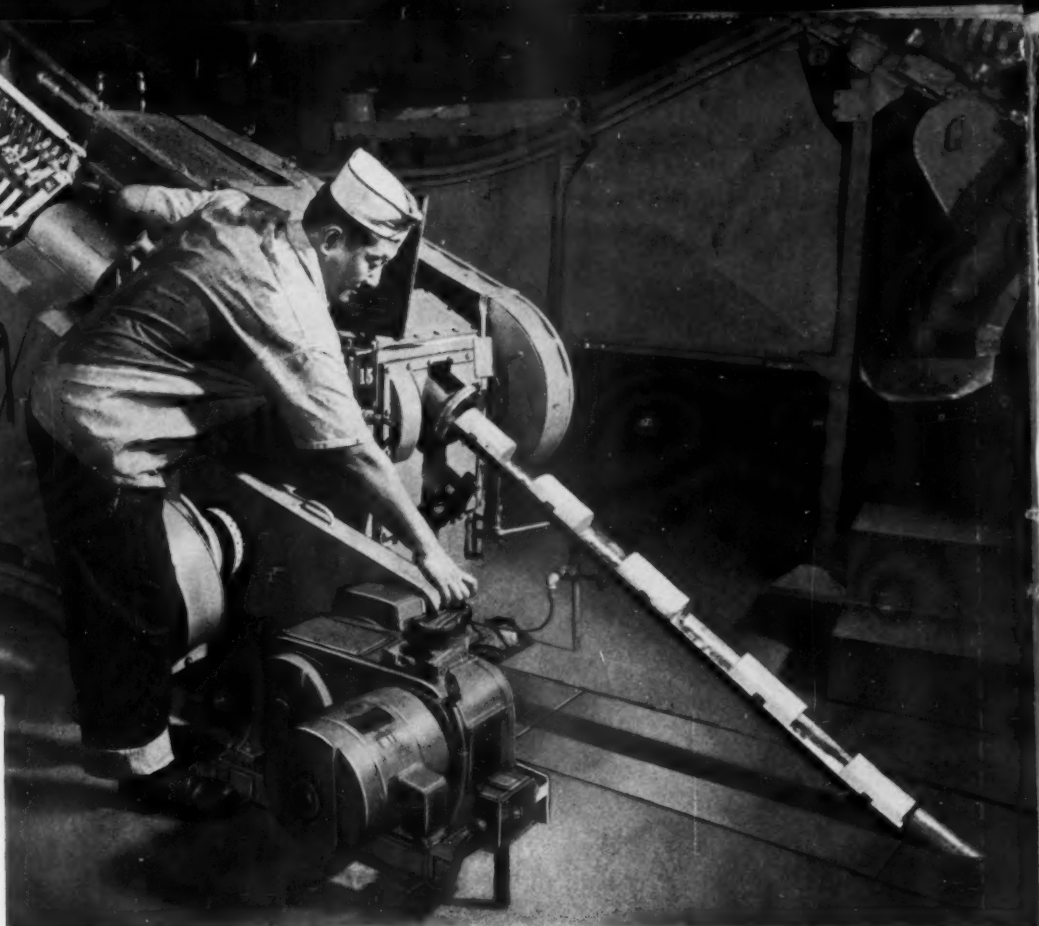
continuously at the same speed, consumes only a fraction of the power formerly needed. The rugged FAWICK units remain maintenance-free despite the abrasive operating environment.

Squeezing more work out of power is just one way FAWICK can help you put extra sales appeal into your cyclic machines. For the complete story, call in your nearest FAWICK representative, or contact the Home Office, Cleveland, Ohio.

### FAWICK AIRFLEX DIVISION FAWICK CORPORATION

9919 CLINTON ROAD • CLEVELAND 11, OHIO  
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada





Mr. R. A. Weaver, Electrical Superintendent,  
Dole Hawaiian Pineapple Company states: **"On the  
basis of evaluation and comparison with other drives...  
We found General Electric Polydyne® Drives  
best meet our adjustable-speed requirements."**

At Dole Hawaiian Pineapple Company's Honolulu Cannery, "Ginaca" processing machines can automatically reduce whole pineapples into separate "components" of core, rind, pulp and a cylinder ready for final processing at a rate of up to 6000 per hour. With a constant-speed motor drive it is necessary to stop and start a Ginaca to control output. However, the Polydyne Drive can match the varying conditions at each stage of the processing system. The adaptability of Polydyne Drives reduces the need for supervisory attention and permits maximum processing efficiency.

Dole Company personnel selected General Electric's Polydyne Drives for the quick and smooth response to speed adjustments demanded by their continuous processing system. As Mr. Weaver also commented,

"In our evaluations and comparisons with other drives we gave particular attention to ease of belt replacement because this makes maintenance simple and reduces downtime. We found Polydyne Drives far superior to other drives for making belt changes quickly."

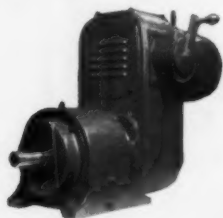
When your application requires low-cost adjustable speed combined with reliability and ease of maintenance, investigate G-E Polydyne Drives. Your General Electric Sales Engineer has full details. Or, write for bulletin GEA-6806, Section 854-05, General Electric Company, Schenectady 5, N. Y.

**GENERAL  ELECTRIC**

Circle No. 31 on Reader Service Card

**GENERAL ELECTRIC  
OFFERS A COMPLETE LINE  
OF LOW-SPEED DRIVES  
1/8 TO 200 HP**

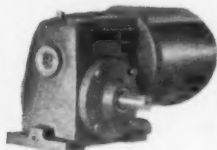
Select from G.E.'s PLUS LINE of compact mechanical power transmission equipment! A full range of ratings is available—many directly from stock.



General Electric Polydyne Drive



Integral-type Gear Motor



Right-angle Shaft Gear Motor



All-motor Gear Motor



Footed Speed Reducer



Shaft-mounted Speed Reducer

Member of  
American Gear Manufacturers' Association

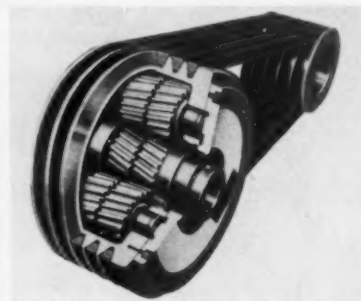
**GENERAL ELECTRIC**

## NEW PRODUCTS

To get complete information on these products, use the Reader Service Cards bound into this issue.

### Rotating transmission

Roto-Mission is a differential planetary gear transmission with high torque capacities and a wide range of reduction ratios up to 270 to 1; additional reduction through motor pulley drive up to 5:1. Nylon splining assures precise timing and mating of all gears and equal load sharing by the planetary gears. Power from the drive motor is transmitted through V-belts which fit in grooves on the



rotating gear case assembly. Control flexibility ranges from use of simple friction reaction arms and hand operated friction clutches to electro-magnetic and torque limiting clutches.

*Airborne Accessories Corp., Hillside, N. J.*

Circle No. 200 on Reader Service Card

### Electro-magnetic clutch/hub

The Cyclehub, a ready-to-install assembly, can be used as either driving or driven member. The package includes a bearing supported adapter hub for mounting a choice of special sheaves, pulleys or sprockets. Open models for either stub or through shaft mounting. Optional shrouded models, with integrally mounted brush holder boxes and protective guard for rotating clutch parts, are supplied for stub shafts only. Cycle-matic power control units available as a circuitry package to provide the

## Make Your Choice Of Clutch While Your Equipment Is In The Design Stage . . .



You can have your machine equipped with either our Over-Center Friction Clutch (left) or our Air-Operated Clutch (right). Each has its advantages depending on the use of the equipment. These clutches come in a wide range of sizes and with gear tooth or Flex-Disc. All are high quality, dependable clutches having low power losses, low upkeep, and long life. Readily adjustable for lining wear. Send for bulletins 5009 (Over-Center), 5011 (Air-Operated), or 5012 briefing our entire line of industrial clutches.

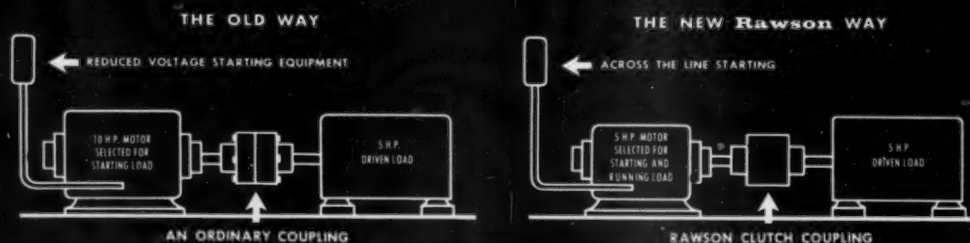
**INDUSTRIAL CLUTCH CORP.**

Waukesha



Wisconsin

Circle No. 36 on Reader Service Card



## HERE'S WHAT RAWSON CLUTCHES WILL DO FOR YOU

**NO-LOAD MOTOR STARTS** — Rawson clutches engage at a pre-selected RPM, therefore motors start under "no-load" conditions. Thus, starting current is lower and motor acceleration time is reduced to a fraction of a second.

**SMOOTH, SHOCK-FREE STARTING** — For any load from fractional to 3,000 horsepower, Rawson starts are smooth and gradual. Even the most delicate equipment and fragile materials are protected.

**NO POWER LOSS** — At normal running speed, Rawson clutches operate with zero percent power loss. Fluid type clutches have at least a 4% loss.

**ACROSS-THE-LINE STARTING** — The purchase of costly reduced voltage starting equipment is no longer required. With Rawson "no-load" starts, motors can utilize low-cost across-the-line starting.

**YOU CAN USE SMALLER MOTORS** — With Rawson "no-load" motor starts and cushioned starting of loads, motor size can be selected for running power only—this may reduce required motor capacity by as much as one-half. Also, on high inertia loads, Rawson clutches eliminate the need for expensive high-torque motors—standard NEMA B motors can be used.

**CONTROLLED ENGAGEMENT** — Centrifugal force causes a Rawson clutch to gradually engage at a pre-selected RPM as it is brought up to running speed. Engagement can be further controlled by using Rawson clutches having a delayed engagement feature. For internal combustion engines and turbine applications, this delayed engagement feature assures "no-load" during warm-up periods. Delayed engagement Rawsons are also ideally suited for dual drive (standby) installations.

**AUTOMATIC OVERLOAD PROTECTION** — Power transmission system components are never subjected to the stresses of a continuing overload—Rawson clutches automatically slip until the overload condition is corrected.

**FREQUENT MOTOR REVERSAL** — Because the Rawson design permits driving in either direction, provides "no-load" motor starts, and assures smooth starting of driven equipment, frequent load reversals are accomplished without overheating the motor.

**REDUCED MAINTENANCE COSTS** — Shock loadings are absorbed by Rawson clutches—stresses are not transmitted to gear trains or other components of drive system. Thus, expensive repairs and downtime are kept to a minimum.



# NEW RAWSON

## CENTRIFUGAL CLUTCHES & CLUTCH-COUPPLINGS

Permit Use of Smaller Motors . . . Lower Starting Equipment Costs . . . Provide Cushioned Starting of Driven Equipment . . . Automatic Overload Protection

Rawson clutches and clutch-couplings are of all-metal construction to assure longer life and maximum horsepower capacity per size. They drive in either direction and provide slip-free power at normal operating speeds for applications up to 3000 horsepower.

Because the Rawson design permits "no-load" starting of motors: acceleration time is much faster; starting current is greatly decreased; across-the-line starting can replace costly reduced voltage equipment; and based on lower starting current required, smaller motors can often be employed.

The cushioned starting feature of Rawson clutches frequently permits using NEMA "B" or standard squirrel-cage motors for high inertia loads instead of expensive special high-torque motors. Also, delicate equipment is protected by this elimination of starting shock. On any type of equipment, overloading or jamming will cause a Rawson clutch to slip—protection is automatic and positive.

Rawson clutches function as direct-drive clutch-couplings (in-line, shaft-to-shaft connection) or as indirect-drive clutches through V-belts, chains or

gearing. For internal combustion engines and turbine applications, Rawsons can be furnished with a delayed engagement feature that provides "no-load" starting and warm-up idling. As the driving unit is accelerated, the Rawson will engage at a pre-selected R.P.M. There is no slipping or power loss at normal running speed. This same delayed engagement feature makes Rawson clutches ideal for dual drive or standby applications—automatic disconnect and predetermined engagement speed is provided for both prime movers.

Rawson clutches are simple in design for economy and reliability; they never require adjustment; heat-checking and brake-fade are eliminated; indirect drive clutches utilize standard "QD" type sheaves and direct drive clutch-couplings use "QD" type bushings for ready adaptability to every standard shaft size.

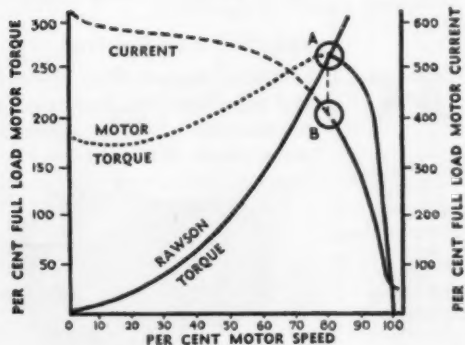
For higher efficiency, lower costs, reduced maintenance and full overload protection, specify Rawson automatic centrifugal clutches and clutch-couplings. These modern centrifugal clutches and their applications are fully described in the Rawson catalog—ask your Rawson distributor or write for your copy.



## FORMSPRAG COMPANY

23587 Hoover Road, Dept. 109-A • Warren (Detroit), Michigan

Precision Power Transmission Products

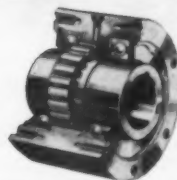


Typical torque and current characteristics of a standard NEMA B motor. Because Rawson clutch does not fully engage until after peak torque speed "A" is reached, motor acceleration time is much faster, peak current period is greatly decreased and motor operates more efficiently "B". Thus, smaller motors and across-the-line starting can be used.

### OTHER FORMSPRAG PRECISION POWER TRANSMISSION PRODUCTS

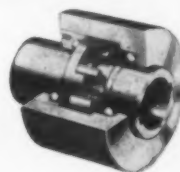
#### FORMSPRAG Over-Running Clutches

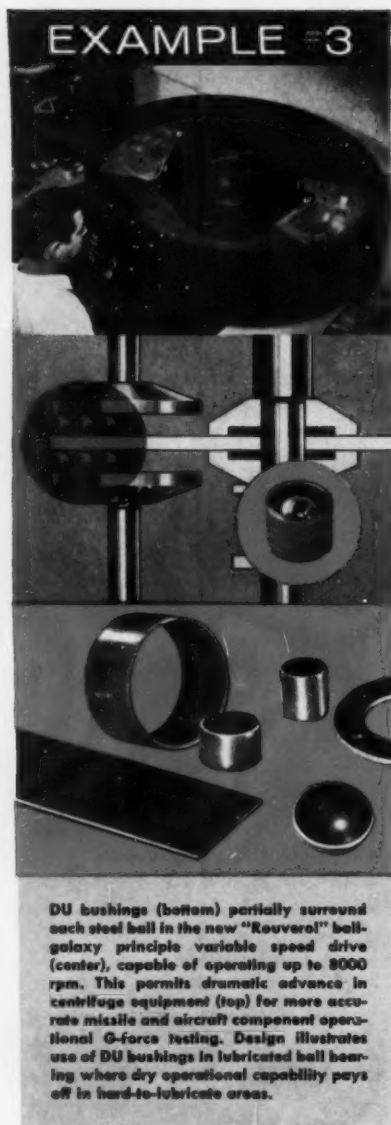
These modern sprag-type clutches provide greatest torque, precision and life on any over-running, indexing or back-stopping application.



#### REVLOK Dual Torque-Locking & Positioning Devices

These multi-purpose devices stop feed-back torque; provide two-directional drive, positioning over-running, back-stopping and load-releasing.





DU bushings (bottom) partially surround each steel ball in the new "Rouveral" ball-galaxy principle variable speed drive (center), capable of operating up to 8000 rpm. This permits dramatic advance in centrifuge equipment (top) for more accurate missile and aircraft component operational G-force testing. Design illustrates use of DU bushings in lubricated ball bearing where dry operational capability pays off in hard-to-lubricate areas.

## DU\* DRY BEARINGS

Solve Another Problem

"Our 909 Variable-Speed Transmission is a high-torque, ball-disc friction drive† which utilizes two clusters of steel balls for the transfer elements instead of the more conventional single-ball configuration. Many bearing materials were tested before a satisfactory cluster cage assembly was evolved. The successful design incorporated DU bushings which are partially swaged around each ball for increased bearing area. In addition to an extremely low coefficient of friction, the bushings transfer heat away from critical areas much more efficiently than other materials tested. Problems concerning wear, and tolerance of foreign particles have virtually disappeared."

R. E. Brown

Vice President—Engineering  
GENISCO, INC.

DU metal is an ideal bearing material for many applications. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings . . . has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives . . . will withstand from -328°F to +536°F.

# GARLOCK

Apply DU dry bearings to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers available for 1/4" to 2" shafts; strip available for special fabrication. Write for engineering catalog DU-458. Special Products Dept., Garlock Inc., P.O. Box 612, Camden 1, New Jersey.

\*Trademark, Glacier Metal Company Ltd.

†Manufactured under license agreement from W.S. Rouveral, University of California at Berkeley



Circle No. 28 on Reader Service Card

## PRODUCTS continued



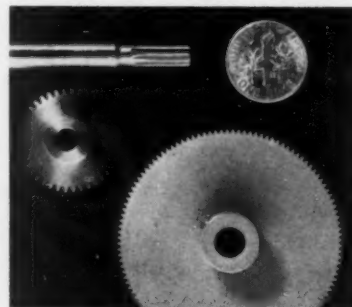
required low current (1/3 amp) dc voltage plus potentiometer selection of acceleration rates. Sizes from 1/2 to 20 hp with a wide selection of standard bores.

Cycledynamics Inc., Detroit, Mich.

Circle No. 201 on Reader Service Card

## Precision spur gears

New line of precision spur gears offers standard sizes from 48 to 120 D.P.—10 to 40 teeth in stainless steel and 42 to 180 teeth in aluminum.



Each gear certified to AGMA Precision Class 1 or better. Outside diameters from 1/10 in. to 2 1/4 in.

Boston Gear Works, Quincy, Mass.

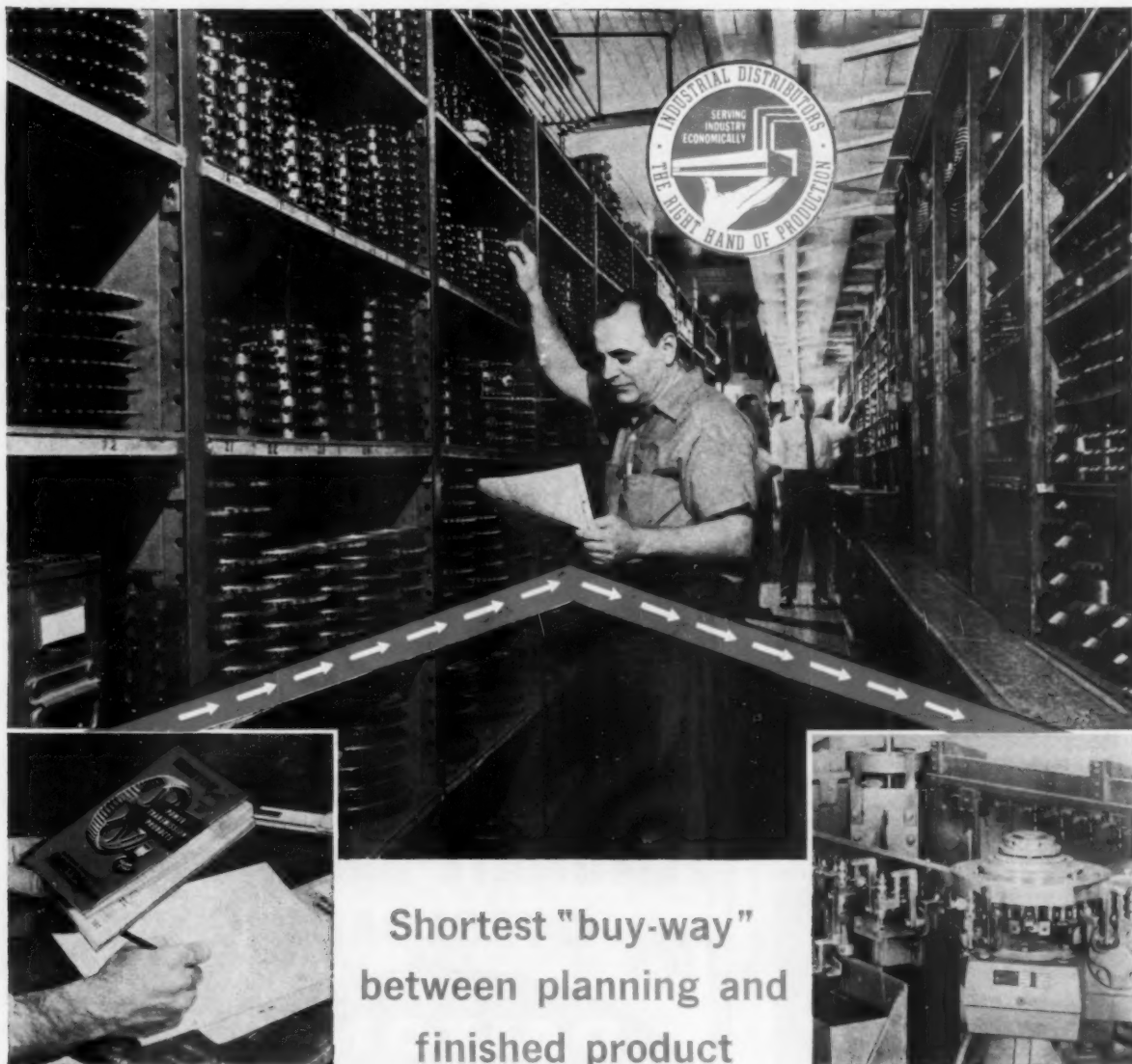
Circle No. 202 on Reader Service Card

## Variable speed drive

The new fractional hp Speed-Trol, said to be one of the lightest and most compact in the industry, offers speed ranges from 4660 rpm to 1.2 rpm



POWER TRANSMISSION DESIGN



**Shortest "buy-way"  
between planning and  
finished product**

**... standardized parts from stock at local Distributors**

When you can get gears, speed reducers, chain and sprockets, bearings and other products of BOSTON Gear quality *off-the-shelf*, at factory prices, from local stocks — why wait for "specials"? Compare costs, and you'll see that "standardization pays" right down the line.

You simplify the design job . . . select components needed from the BOSTON Gear Catalog . . . order all from one local source . . . and get products top-rated for performance and service life.

You save on inventory expense . . . get supplies as

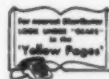
needed from Distributors' full stocks. With BOSTON Gear components in products you make and sell, you protect your customers against replacement delays and downtime. Anywhere in industrial U. S. or Canada, there's a BOSTON Gear Distributor nearby to make prompt delivery.

Call your Distributor, and learn how his factory-trained specialists can make "standardization pay" most for you. Boston Gear Works, 94 Hayward Street, Quincy 71, Massachusetts.

*Adv. copyright by Boston Gear Works*

CALL YOUR  
NEARBY

**BOSTON** *gear*  
**DISTRIBUTOR**



— **STANDARDIZATION PAYS** —<sup>®</sup>

Circle No. 71 on Reader Service Card



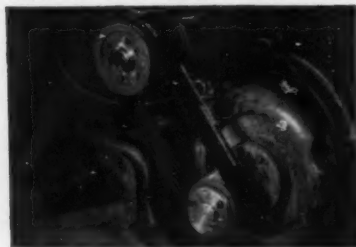
## WOOD'S POWER TRANSMISSION PRODUCT NEWS



### NEW, NON-FREEZING VARIABLE

Wood's new "SVS" stationary control, variable speed drive has positive locking collars and other, patented features which eliminate freezing, assure easy speed change. No lubrication is required. Uses standard v-belts and stock companion sheaves. Write for Bulletin 6102.

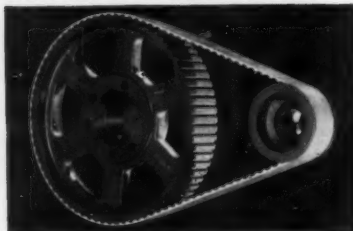
Circle No. 66 on Reader Service Card



### NEW, TREMENDOUS SAVINGS

Wood's new Ultra-V Drives handle up to 3 times more horsepower than conventional v-belt drives in a given space... reduce overall drive dimensions as much as 50%... cut weight up to 25% and costs up to 30%. Write for Bulletin 9102.

Circle No. 67 on Reader Service Card



### POSITIVE ACTION—LONG LIFE

Wood's Timing Belt Drives provide positive, slip-free action. Belts are all muscle. No high initial tension, tension devices or lubrication needed. Drives are light weight, compact... quiet and clean. Wide load and speed range. Equipped with famous Sure-Grip Bushings. Write for Bulletin 2100.

Circle No. 68 on Reader Service Card  
MP/3608



**T. B. WOOD'S SONS COMPANY**

CHAMBERSBURG, PENNSYLVANIA  
ATLANTA • CAMBRIDGE • CHICAGO  
CLEVELAND • DALLAS

## PRODUCTS continued

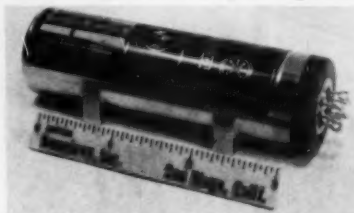
with up to 10-1 variation in  $\frac{1}{4}$ ,  $\frac{1}{2}$  and  $\frac{3}{4}$  hp ratings. NEMA standard dimensions for shaft height and diameter allow substitution for standard motors. It can be supplied with single or three phase motor with drip-proof, totally enclosed or explosion proof construction. May be foot-mounted in any position or furnished with face mounting bracket. Available with right angle and helical gears.

*Sterling Electric Motors, Los Angeles, Calif.*

Circle No. 203 on Reader Service Card

### Tiny dc rate gyro

Only  $1\frac{1}{8}$  in. diameter,  $3\frac{3}{4}$  in. long and weighing 8 oz, this 28 volt dc gyro will take unlimited altitude, severe acceleration, vibration and shock. Steel flexure pivot gimbal



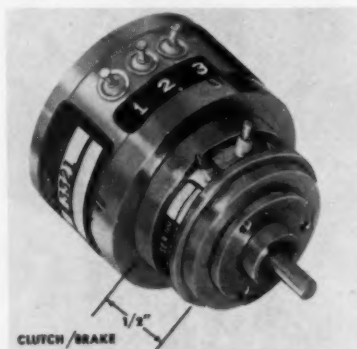
suspension and heavy metal rotor ensure low hysteresis (0.5% max) and high accuracy (1%). Service life of the motor is over 300 hours. The pot has a life of more than 106 cycles.

*Humphrey, Inc., San Diego, Calif.*

Circle No. 204 on Reader Service Card

### Clutch/brake pot module

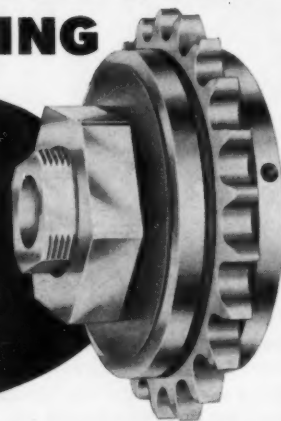
Consists of a combination of an electro-magnetic clutch/brake with a potentiometer in a single permanently sealed unit with a common shaft and integral bearings. Problems of coupling backlash, shaft misalignment, end play and excessive bearing drag are eliminated. The Pancake



## ELIMINATE BREAKDOWNS due to OVERLOADING

**DALTON  
"OSD"  
OVERLOAD  
SAFETY DEVICE**

PAT. APPLIED FOR



Ideal for use in conveyors, presses, farm machinery, construction equipment, material handling machines and applications of power transmission equipment.

- ALL STEEL CONSTRUCTION
  - FEWER PARTS
  - TORRINGTON NEEDLE BEARINGS LUBRICATED FOR LIFE
- TERRITORIES AVAILABLE FOR DISTRIBUTORS

**DALTON**  
gear company

1750 HENNEPIN AVE., MINNEAPOLIS 3, MINN.

Manufacturers of  
GEARS  
SPROCKETS  
COUPLINGS  
ROLLER CHAIN

Circle No. 15 on Reader Service Card

POWER TRANSMISSION DESIGN





*"Sure-Flex" Coupling's unique design, 4-way flex are . . .*

## A "SURE CURE" FOR SHOCK, VIBRATION, SHAFT MISALIGNMENT

Unique design and 4-way flexing action enable Wood's "Sure-Flex" Couplings not only to absorb all types and combinations of angular and parallel misalignment and end-float . . . but from 5 to 15 times more shock and vibration than other leading flexible couplings. There are only four basic parts which lock together without clamps

or screws, tightening securely under torque to provide smooth, dependable power transmission. There is no metal-to-metal contact, no wear, no need for lubrication or maintenance. "Sure-Flex" Couplings are easily installed, unaffected by abrasives, dirt or moisture. Operation is noiseless. Get all of the facts. *Write for Bulletin 5103.*



**T. B. WOOD'S SONS COMPANY • CHAMBERSBURG, PENNSYLVANIA**

SF/160A

ATLANTA • CAMBRIDGE • CHICAGO • CLEVELAND • DALLAS

Circle No. 69 on Reader Service Card

NOVEMBER, 1960

55

• **What is this writer trying to say?** "In instances of mobile applications where fluid temperature due to intermittent operation and continued exposure remains low, a high-viscosity-index, low-pour-point fluid would be mandatory for reliable operation."

• **What he wants you to know is this:** "Machines used outdoors in winter need oil that isn't affected by the cold." Well if that's what he meant, why didn't he say so? Good question. The reason you have to hack your way through doubletalk in some technical and business magazines is that writing things clearly and simply is hard work—a lot harder and much more expensive than putting them down in technicalese (the special language of engineers and longhairs.) The odd part of this problem is that even the longhairs who *write* technicalese don't like to *read* it. That is why the articles in this magazine have been distilled.

## Distilled Writing gives you facts without fluff

Our research department told us that we—like other publishers—were taking too much of our space and your time to get the facts across. That's where Distilled Writing comes in.

• **WHAT'S DISTILLED WRITING?** It's copy with the extra words squeezed out. It gives each article exactly as much space as it really needs . . . not one line more! This isn't a digesting process: all the facts are still there, but the verbiage is gone. For example, we take this kind of writing . . . and distill it to this:

eliminate unwanted vegetation	kill weeds
It is used to rupture missile frames in flight to initiate aerodynamic distintegration.	It makes missile frames explode in flight.
formation of iron oxide binding the two surfaces	rusted together



Distilled Writing is the registered service mark of The Industrial Publishing Corporation

• **HOW WE DEVELOPED DISTILLED WRITING.** First we hired Dr. David Kinsler to head up our distilling on a fulltime basis. He works with all our editorial staffs, teaching sharp, concise writing. Second, we retained Robert Gunning, the top authority on readable writing, as our consultant. Third, we put every line of copy—whether staff-written or by an expert in the field—through the distilling process before it goes to the printer. Our whole editorial effort is aimed at telling the story brightly, clearly, briefly.

• **WHAT DOES THIS MEAN TO YOU?** The story that used to take four pages is now told in two or three. Shorter articles mean more of them in each issue. You get more information for your reading time and you don't have to dig it out. It takes more work for us to do it, but Distilled Writing pays off in the time it saves for our busy readers.

**PRODUCTS continued**

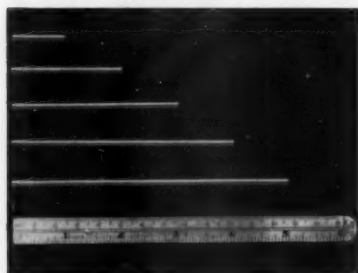
clutch/brake has an extra length shaft coupled to the potentiometer winding cup by a specially-machined end cap. Output shaft of the clutch/brake is the rotating shaft of the potentiometer. Extremely close tolerances in machining bearing bore and winding cup mounting recess prevent eccentricity. Shock and acceleration forces of over 100 G have no effect on performance.

*Autotronics Inc., Florissant, Mo.*

Circle No. 205 on Reader Service Card

**Precision ground shafting**

Comes in OD's of .12475, .18725 and .24975, with a straightness of .0002 in./in., .00015 in./in. and .0001 in./in. respectively. Extreme OD toler-



ance is from +.0000 to -.0001. Material #303 stainless. Dynaco chamfered type shafting is available in a range of overall lengths of 1 in. to 5 in. ( $\pm .010$ ). Surface finish does not exceed RMS-8. All shafting can be ordered from stock.

*Dynamic Gear Co., Amityville, N. Y.*

Circle No. 206 on Reader Service Card

**Precision miniature motors**

Twenty four hour delivery on many styles and types of precision miniature motors is a new company service. Types in stock include permanent magnet dc motors up to 1 1/4 in. diam. (to 1/65 hp at 12000 rpm) and ac types up to 1.675 in. diam. (1/60 hp at 12,000 rpm).

*Globe Industries, Inc., Dayton, Ohio.*

Circle No. 207 on Reader Service Card

**Ball screw and spline assemblies**

Standardized ball screw and ball spline assemblies of 90% efficiency



# **TRIAL SAMPLES** Of World-Famous **WHITMORE'S** Lubricants



**OPEN CHAIN LUBRICANT**  
**INCREASES CHAIN LIFE UP TO 300%**

Penetrates, lubricates, prevents rust. Lubricates deep into chain linkage to reduce friction on pins, rollers, bushings, pressure surfaces. Corrosion inhibitor prevents rust in vital working mechanisms. Lubricates close-tolerance internal surfaces to increase chain life up to 300%. Highly recommended for all climatic conditions to stop rust and corrosion even in salt atmospheres.

Packaged in handy 16 oz. aerosol spray-on containers or in bulk—send for a free trial sample.



**ANTI-FRICTION COMPOSITIONS**  
**HAVE NO MELTING OR DROPPING POINT**

Packaged in 1 1/2 oz. cartridges for handy application with lever-type cartridge guns for constant protection to roller, ball, sleeve bearings and sliding surfaces in "hot" bearing applications or in areas with high ambient heat. Exclusive formulas have no melting or dropping point; moisture resistant; will not wash out; exceptional metal adherence properties; temperature reducing qualities; high extreme pressure values. Available in two grades. Whitmore's Anti-Friction Composition No. 1 (light density), recommended for high speed, high temperature applications. Anti-Friction Composition No. 2 (heavy density), for low-speed high-temperature applications or loosely-fitted bearings. Specify No. when requesting free trial sample.

**68 YEARS OF LEADERSHIP LUBRICATING THE FOLLOWING:**

- Open Gears, Dipper Sticks, Cams • Open and Enclosed Chain • Speed Reducers
- Enclosed Gear Cases • Roller, Ball and Sleeve Bearings • Wire Rope and Cable
- Hydraulic Units, Torque Converters



Est. 1893  
**THE WHITMORE MANUFACTURING CO.**

LUBRICATING ENGINEERS  
CLEVELAND 4, OHIO • VULCAN 3-7272

Circle No. 65 on Reader Service Card

NOVEMBER, 1960

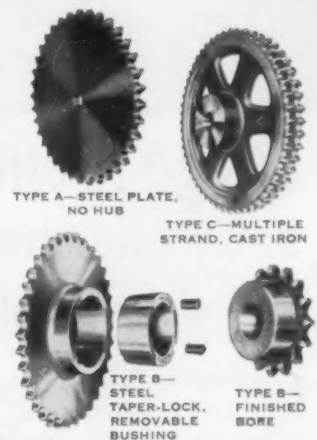
for power transmission

# **DIAMOND** **Roller Chain & Sprockets**



**SINGLE, DOUBLE & TRIPLE STRAND CHAIN**

**STOCK SPROCKETS**



TYPE A—STEEL PLATE, NO HUB

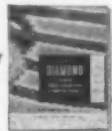
TYPE C—MULTIPLE STRAND, CAST IRON

TYPE B—STEEL TAPER-LOCK, REMOVABLE BUSHING

TYPE D—FINISHED BORE

◆ It's sound engineering to use stock **DIAMOND** Roller Chain for efficient drives, even on the most highly specialized machinery. Standard **DIAMOND** Roller Chain and stock Sprockets shorten development time, cut power transmission design costs, lower production costs. For power transfer, precision timing, conveying—whatever the application—traditionally high quality **DIAMOND** Roller Chain Drives assure long, continuous, trouble-free performance... easy, economic maintenance.

Write now for your copy of latest **DIAMOND** Chain and Sprocket Catalog!

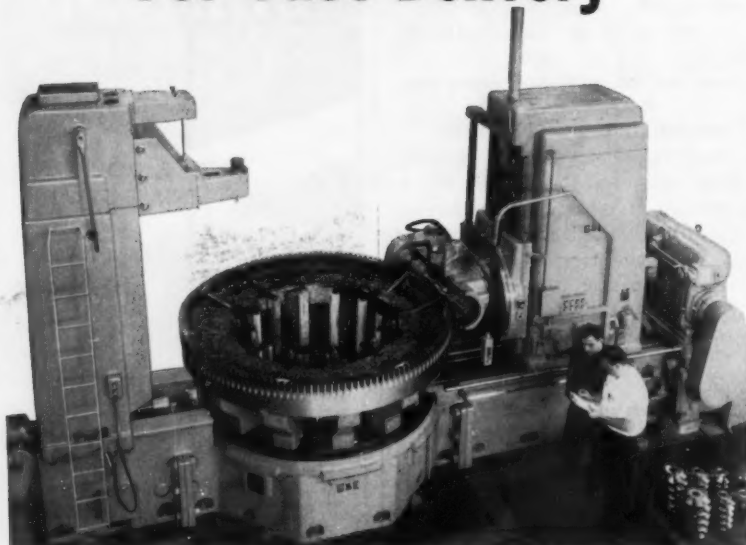


**DIAMOND CHAIN CO., Inc.**

A Subsidiary of  
American Steel Foundries  
Dept. 718 • 402 Kentucky Avenue  
Indianapolis 7, Indiana

Circle No. 21 on Reader Service Card

# New Production Capacity For Fast Delivery



## Large Generated Gears SPUR • HERRINGBONE • HELICAL for a wide range of industrial applications

Gears which must operate smoothly and without vibration at higher speeds and under greater loads must correspondingly be more accurate in tooth profile and spacing.

H & S Generated Gears answer these demands.

Offering the same high-quality standards which characterize the complete H & S Gear line, production capacities for large generated Spur, Helical and Hobbled-Herringbone Gears are now available in the following dimensions:

- Up to 80" outside diameter at 1 DP
- Up to 90" outside diameter at 1 1/4 DP
- Up to 100" outside diameter at 1 1/2 DP
- Up to 125" outside diameter at 2 DP

Face widths up to 42", depending on helix angle

Send your specifications, or let our technical staff make recommendations. H & S specializes in fast production of quality industrial Gearing and Speed Reducers to meet your custom requirements.

Write for Catalog FLB-60



## The HORSBURGH & SCOTT CO.

5112 Hamilton Avenue • Cleveland 14, Ohio  
Circle No. 35 on Reader Service Card

### PRODUCTS continued

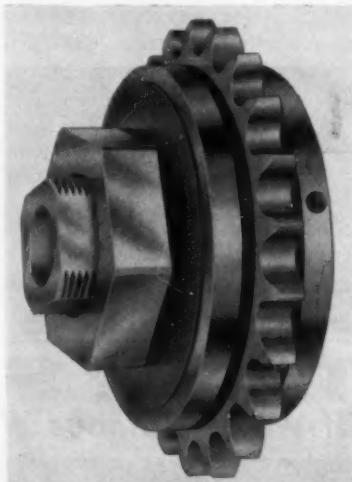
are intended for applications where costs prevent the use of extreme precision types. Suitable for jobs where loads with low break-away friction have to be moved by a small-space assembly needing very little maintenance.

Beaver Precision Products, Inc.,  
Clawson, Mich.

Circle No. 208 on Reader Service Card

### Overload safety device

Made of carbon steel, the Dalton OSD uses needle bearings, has a minimum of parts and is lubricated for life. Clutch facing resists moisture



expansion and allows more constant torque. Flanges are surface ground to approximately 32 micro finish. Other features include induction-hardened races and machine-squared threaded hub and pressure plate.

Dalton Gear Co., Minneapolis, Minn.

Circle No. 209 on Reader Service Card

### Quick-disconnect flexible shaft

Using the spring ball method, the HD Type shaft can be connected or disconnected at either end by a flick of the wrist. Features high speed ball bearings at each end and couplings that can be bored to suit and attached with set screws. Sizes 3/8, 1/2 or 5/8 in.



POWER TRANSMISSION DESIGN



# Here's your **BEST BUY** in multi-speed transmissions

## Most Complete Range of Gear Ratio Combinations

# 1

- Over 500 Gear Ratio Combinations in 2-speed line
- Over 5,000 Gear Ratio Combinations in 3-speed line
- Over 5,000 Gear Ratio Combinations in 4-speed line
- Over 3,000 Gear Ratio Combinations in 6-speed line
- Over 3,000 Gear Ratio Combinations in 9-speed line
- Plus a variable-speed line and an automatic line

# 2

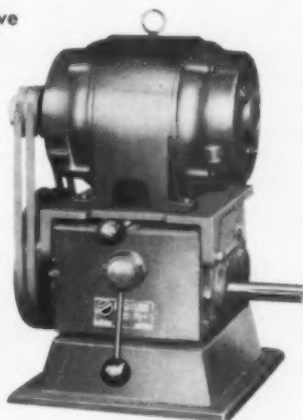
## The Most Efficient Transmission of Its Kind

TURNER'S Unique Design, its positive drive, and its high standard of quality insure high degree of job efficiency . . . does more work for less money.

# 3

## Compactness

To save precious space, which is important to every design engineer, TURNER Multi-Speed Transmissions permit the motor to be mounted on top of the transmission, giving the utmost in compactness.



# 4

## Flexible Shaft Locations A Turner Exclusive

TURNER'S Unique Design with its extreme flexibility offers as many as 8 different standard shaft locations, plus many others in 3 and 4 shaft Multi-Speed Transmissions. Output shafts can be left or right hand, forward, rear, or center mounted, depending upon arrangement. Two output shafts can be furnished, offering two different output speeds simultaneously from one input speed to the transmission, to the great delight of design engineers.

# 5

Service is What You Want, and Service is What We Aim to Give You! TURNER offers a total of 16,500 different gear ratio combinations in its 2, 3, 4, 6, and 9 speed lines. Stock units (short delivery)—Standard units (8 weeks delivery)—Special units (12 weeks delivery).

If TURNER doesn't have it, chances are it is not available anywhere.

Write today for your copy of our new comprehensive catalog containing complete selection and application data.

**Turner**  
**Transmissions**  
DIVISION

## TURNER UNI-DRIVE COMPANY

3416 Terrace Street  
Kansas City 11, Missouri

Circle No. 57 on Reader Service Card



## Helicals and Spiral Gears—precision-made of any material—with famous G.S. uniformity!

Whatever basic material your application calls for, Gear Specialties can give you Helicals and Spiral Gears of consistently superior quality, made with the precision for which G.S. is famous. That means your production isn't slowed down by rejects or imperfections—and your product will perform smoothly and efficiently in the hands of your customers.

It's this unvarying G.S. quality—backed by unsurpassed experience, craftsmanship, equipment, production control—which leads top-name manufacturers in all divisions of industry to make G.S. their Number One source for not only Helicals and Spiral Gears, but for Fine and Intermediate Pitch Gearing of all types, in all quantities.

Get your Gear job done better—put G.S. in your picture now!



### SEND FOR FREE

Small Gearing Guide. Contains useful charts. Send for your copy today!



# GEAR

## Specialties, Inc.

2635 WEST MEDILL AVENUE  
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS  
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS  
OF FRACTIONAL HORSEPOWER GEARING

Circle No. 30 on Reader Service Card

Circle No. 22 on Reader Service Card



## Cut a KEYWAY for ONE CENT

### Minute Man KEYWAY BROACH KIT

In one minute and for as little as one cent you can cut a keyway with the Minute Man Keyway Broach Kit. For keyways from  $\frac{1}{16}$ " to 1" in any bore from  $\frac{1}{4}$ " to 3".

SAVE  
MONEY WITH  
THESE OTHER  
STANDARD  
STOCK  
BROACHES

**SQUARE BROACHES** —  $\frac{1}{8}$ " to  $\frac{3}{4}$ " holes  
**HEXAGON BROACHES** —  $\frac{1}{8}$ " to  $\frac{3}{4}$ " holes  
**ROUND BROACHES** —  $\frac{1}{4}$ " to 1" holes

SEND FOR CATALOG  
AND PRICE LIST

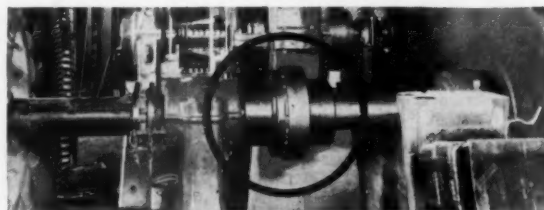
The duMont Corp.  
Greenfield, Mass.

MAIL FREE BROACH CATALOG AND  
PRICE LIST P describing Square Broaches,  
Hexagon Broaches, Production Type Keyway  
Broaches and Keyway Broach Kits to

Name.....  
Company.....  
Address.....



duMONT



## "Most Trouble-Free Heavy-Duty Couplings We've Ever Used"

This is a typical report received from users of Lovejoy Types C and H Heavy-Duty Flexible Couplings... and they give many reasons why:

- Easily installed and aligned in minutes, using only a straight edge.
- Completely unaffected by dirt, dust, mud, water and weather.
- Lubrication-free and uncomplicated by mechanisms that require frequent adjustment and maintenance.
- Cushions can be removed without disturbing the line and advanced or reversed on non-reversing loads for double life.
- Metal jaws never wear out because service rated cushions transmit the load.

Lovejoy Heavy-Duty Couplings are available in a full range of bore sizes and types at ratings to 4250 hp. (1200 rpm.). Request full information on the size and type best suited for your job. Ask for Catalog C-58.

### LOVEJOY FLEXIBLE COUPLING CO.

4852 WEST LAKE STREET, CHICAGO 44, ILLINOIS  
Telephone ESlebrook 9-3010 Teletype TWX-CG-85

Circle No. 41 on Reader Service Card

POWER TRANSMISSION DESIGN

#### PRODUCTS continued

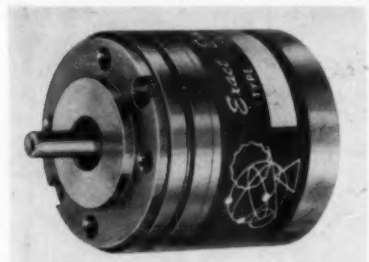
core, maximum torque of 220 in. lb. Music wire core, lined with spring steel reinforced with wire braid, covered with neoprene impregnated fabric and abrasion resistant rubber jacket.

Stow Mfg. Co., Binghamton, N. Y.

Circle No. 210 on Reader Service Card

#### Miniature servo gearhead

Model E11, latest addition to the company line, comes in almost 1000 ratios from 3.08:1 to 16,384:1, using two to seven gear stages and a motor output pinion with either 10, 12, 13 or 15 teeth. Designed for mounting



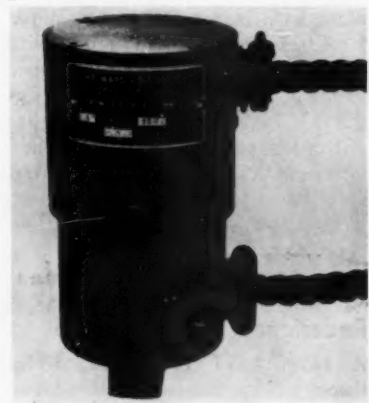
to standard size 11 motor, adapters are available for mounting to standard size 10, 15 or 18 motors. Special feature is the incorporation of an integral output spur and output shaft with the output shaft fully supported between bearings. Output torque is 25 oz in. continuous, starting torque .015 oz in. max. Backlash through the gear train is less than 45', for the two stage unit, less than 30', for all other units. Maximum weight is 3.820 oz.

Exact Engineering and Mfg. Co., Oceanside, Calif.

Circle No. 211 on Reader Service Card

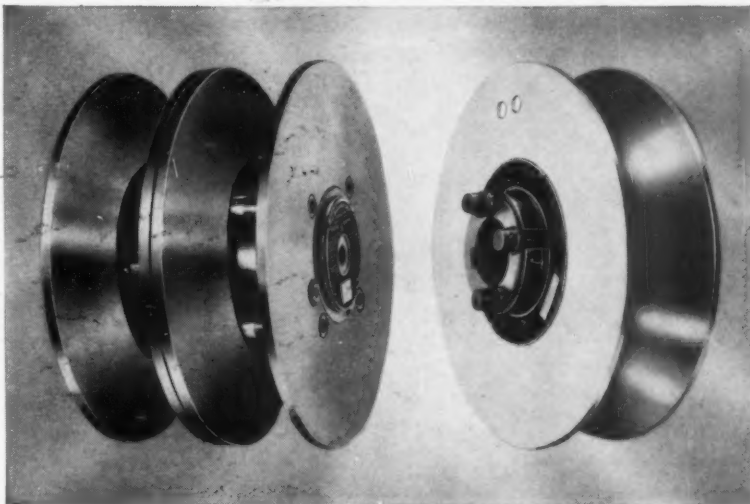
#### Rotating electrical connector

Originally designed to connect attachments on rotating machine tool parts, this swivel connector allows



NOVEMBER, 1960

## **AP** NOW OFFERS THE MOST COMPLETE LINE OF WIDE-RANGE ADJUSTABLE-SPEED DRIVES FROM STOCK



Single groove drives in "Q", "R", and "W" cross-section transmit up to 20 hp.  
Double groove drives in "R" cross-section transmit up to 30 hp.

Order from 7 sizes and 4 models of AP Wide-Range Adjustable-Speed Drives. Single groove drives in "Q", "R", and "W" belt cross-section width transmit up to 20 hp. And double-groove drives in "R" belt cross-section widths deliver up to 30 hp.

Previously made on special order for textile machinery manufacturers, AP 2-R Groove Adjustable-Speed Drives are now being made for Stock. Intended for use on machines where a heavy duty, dependable, economical adjustable-speed drive is needed, they are ideal for replacement of existing overloaded drives—and new installations—where increased capacities are required.

AP Wide-Range Adjustable-Speed Drives are the economical, compact and positive form of speed control. Furnishing quiet, accurate adjustment (up to 2:1), they insure proper drive speed for all applications.

#### FEATURES:

- 1 Exclusive double-tapered hub locks flanges securely—permits stepless, accurate speed adjustment. Small or large adjustments are precise and permanent, no freezing.
- 2 Precisely machined and dynamically balanced, all sheaves are strong, quiet running, long-lasting and trouble-free.
- 3 Simultaneously moving flanges insure correct belt alignment at all times.
- 4 Companion Sheaves feature Q-D Bushings. Easily installed or removed, they grip shaft firmly.

Your AP Distributor will tell you why more mill men are specifying AP Adjustable-Speed Drives. See him! His experience and engineering know-how will prove that it pays for you to standardize on AP.



**THE AMERICAN PULLEY COMPANY**

4200 WISSAHICKON AVENUE • PHILADELPHIA 29, PA.

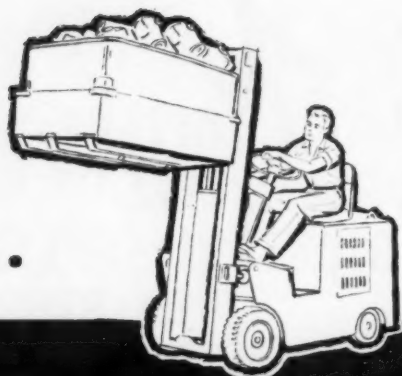
A division of VAN NORMAN INDUSTRIES INC.

Circle No. 4 on Reader Service Card



2652.

**from  
LITTLE  
LIFTS ...**



**to SUPER SEMIS**

Both are driven by Rockford Spring-Loaded Clutches. Rockford offers today's design engineer an ultra-wide range of proven power controls for automotive, agricultural and industrial machinery. Rockford's complete engineering design service is available to you at no cost or obligation. All clutches are quality-built and thoroughly tested for enduring dependability . . . customers stay customers. Write today for illustrated brochure.



SPRING-LOADED  
ROCKFORD CLUTCH

**ROCKFORD CLUTCHES**

ROCKFORD CLUTCH DIVISION

BORG-WARNER



1331 EIGHTEENTH AVE.  
ROCKFORD, ILLINOIS

Export Sales  
Borg-Warner International  
34 So. Wabash, Chicago, Ill.

Circle No. 51 on Reader Service Card

#### PRODUCTS continued

electrical lines and conduit to be rotated without twisting. Silver plated contacts and lube-free ball bearings cut out maintenance problems. Various configurations and types of connectors available, including axial connectors for rotating or oscillating applications. Inlets will accept rigid conduit, flexible B-X cable and all standard heavy duty electrical wiring for single or 3-phase motors. Normally drip-proof, but completely enclosed models by order. Standard type 5 hp (220 volt at 15 amps). Size is 2 1/2 in. diam by 5 in. long.

Ward-Riddle Co., Ravenna, Ohio

Circle No. 212 on Reader Service Card

#### Pillow block unit

Known as the PBS, this new line takes shaft sizes from 1/2 to 1 7/16 in. Pressed steel housings keep the costs down, but bearing-to-housing fit is



to precision standards. Suitable for lightly loaded power shafts with relatively little thrust, as in fans, conveyors etc.

Fafnir Bearing Co., New Britain, Conn.

Circle No. 213 on Reader Service Card

#### Size 11 motor generator

Generator is produced both integral with size 11, 60 cycle motor and as a separate unit. Dimensions of motor generator combination are 1.062 in diam. by 3 in. long. Generator alone measures 1 11/16 in long, with characteristics that include a scale factor of 2.7 volts per 1000 rpm, signal-to-noise ratio of 100 and an input power of 3.5 watts. Motors and generators come with voltage ratings from 26 to 115 volts.

Daystrom, Inc., Transicoil Div., Worcester, Pa.

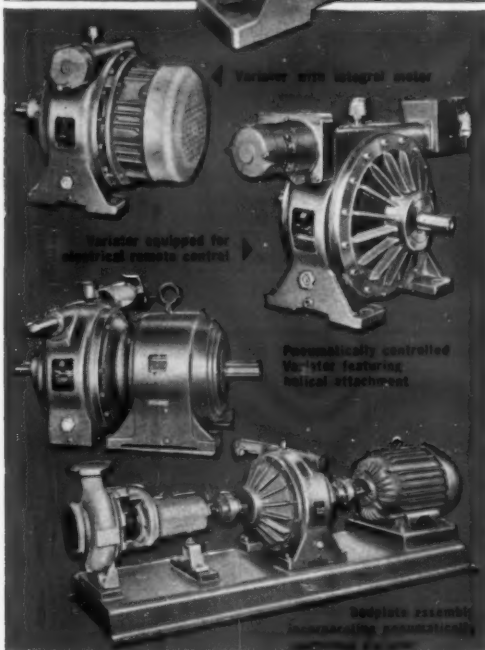
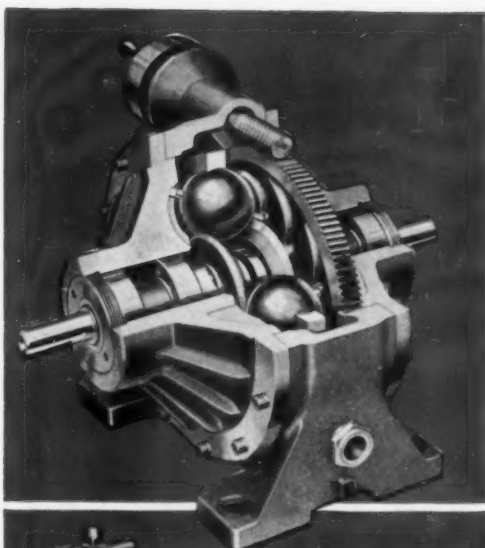
Circle No. 214 on Reader Service Card

#### Redesigned gearshift drive

A redesign of Type RC3, 1 hp through 5 hp, makes available lower

POWER TRANSMISSION DESIGN





*for accurate, dependable,  
infinitely variable  
speed control, specify...*

## CLEVELAND SPEED VARIATOR

Cleveland Speed Variators are simple in operation . . . built for long life. Eighteen models—including a new motorized unit—range from fractional to 16 hp at 1750 input RPM. They all accurately provide dependable, infinitely variable speed control over a full 9:1 range—from  $\frac{1}{2}$  to 3 times input speed. Instant smooth change of output speed can be adjusted by either manual, automatic or remote control. Precise adjustments are always made with accurate adherence to settings.

### Exclusive Variator advantages:

- An extremely compact unit with input and output shafts in line and rotating in the same direction.
- Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.
- Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.
- Speeds infinitely variable over entire range of adjustment.
- No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.
- Long life and minimum maintenance due to absence of belts or complicated linkages.
- Ample bearing support for overhung pulleys on both input and output shafts.

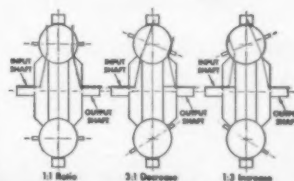
Write today for free Bulletins and Data Sheets shown at left. They contain detailed description, photographs, sectional drawings, rating tables and specifications for the versatile Variator.

### Cleveland Worm & Gear Division

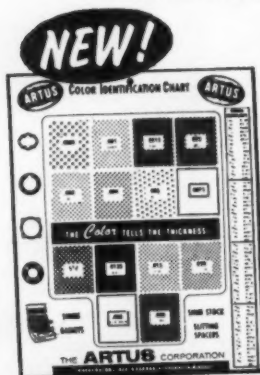
Eaton Manufacturing Company  
3273 East 80th Street • Cleveland 4, Ohio



Power is transmitted from input shaft to output shaft — rotating in the same direction — through alloy steel driving balls which are in pressure contact with the drive discs. Relative shaft speeds are adjusted by changing position of axles on which the balls rotate.



Circle No. 6 on Reader Service Card



# A 'MUST' WHEREVER SHIMS ARE USED

## ARTUS PLASTIC SHIMS

THE COLOR TELLS THE THICKNESS

**FREE**  
Write for this  
handy COLOR  
CHART, today!

Artus Plastic Shims are real time savers in production and maintenance. They're used by many of America's best known industrial corporations because they're more efficient, more convenient, always available.

Custom shapes to your specifications.

Write for Samples and Literature  
or Mail Blueprint for Test Sample.

THE **ARTUS** CORPORATION  
201 South Dean St. • Englewood, New Jersey  
LOwell 7-0900  
formerly INDUSTRIAL PRODUCTS SUPPLIERS

# specify **PRECISION UNIVERSAL JOINTS**

**1st choice**  
for dependable  
power transmission!

Power take-off at an angle required? Precision Universal Joints are preferred because of exclusive design features: manufactured of aircraft steel, uniformly hardened and machined to precise tolerances. Same size parts are interchangeable. Available blank, bored, broached, threaded, cross drilled or tapped according to your exact specifications!

**Need more  
information?**

Clip this ad and  
attach to your  
letterhead for  
FREE folder.  
PTD-110

**PRECISION TOOL & MFG. CO. of Illinois**

1305 S. LARAMIE AVENUE / CICERO 50, ILL.

Circle No. 49 on Reader Service Card

Circle No. 17 on Reader Service Card

# SIMPLIFY YOUR RIGHT ANGLE POWER TRANSMISSION PROBLEMS...



YOUR DESIGN DESERVES THE CROWN GEAR "PACKAGE".

- Totally enclosed Aluminum Alloy Housing
- 316 Stainless Steel Shafts • Double Sealed Ball Bearings • Hardened Steel, Spiral Bevel Gears
- Choice of 4 or 5 Mounting Positions • Ratings from 1/4 through 2 H.P. • 1:1 or 2:1 Ratio optional

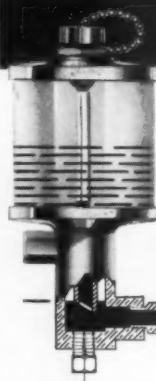
Contact your local distributor or  
write direct for new catalog...



**CROWN GEAR**  
320 PARK AVE., WORCESTER 10, MASS.

A Division of Harrington & Richardson, Inc.

# Exclusive new design!



## **Oil-Rite** CONSTANT LEVEL OILER

OIL LEVEL

Protects bearings by  
automatically maintaining  
a constant oil level.

Compare these  
**BETTER DESIGN FEATURES!**

- New top filler cap — no need to remove reservoir
- Rugged reservoir construction — reduces breakage
- Remote mounting if desired
- Extra-high surge level
- Dustproof construction

Only Oil-Rite Constant Level Oilers bring you all these greatly improved features.

There are many applications where they can be used advantageously to maintain oil at a constant level. Ring oiled and anti-friction bearings, gear boxes, pillow blocks, pump housings, etc. are only a few ideal installations.

Let us show you how these and other new Oil-Rite developments can save you costly maintenance and down time through better lubrication.

Complete application engineering service available.  
Send for **FREE** catalog today.

OILING SYSTEMS • VALVES  
DISPENSERS • OIL GAUGES  
CHAIN OILERS • OIL CUPS

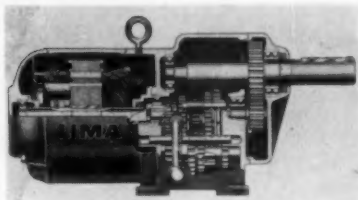
**Oil-Rite**

CORPORATION  
2329 Waldo Boulevard, Manitowoc, Wis.

Circle No. 47 on Reader Service Card

**POWER TRANSMISSION DESIGN**

**PRODUCTS continued**



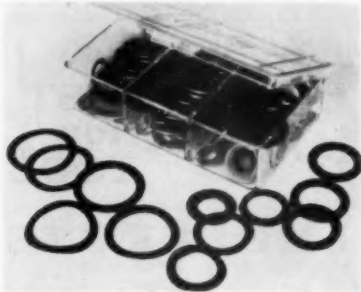
output shaft speeds for handling severe loads. Extra heavy steel output shaft is mounted on widely spaced ball bearings to support overhung loads. Gear change lever for the 4 gear changes can be placed in four optional positions. Simple shift mechanism is positive and easy to operate. For polyphase ac power supplies of standard frequencies (25-50-60 cycles) and voltages below 600.

*Lima Electric Motor Co., Inc., Lima, Ohio.*

**Circle No. 215 on Reader Service Card**

**Nylon thrust washers**

Molybdenum disulphide-filled nylon is used in Nylatron GS washers with advantages of higher heat distortion tolerance, greater rigidity and dimensional stability, plus no lubrication needed. A pocket-sized utility



kit containing over 100 washers in 39 sizes of 1/64, 1/32 and 1/16 in. thickness can be had for \$3. Suitable for light thrust jobs.

*Hardware Designers, Inc., South Hackensack, N. J.*

**Circle No. 216 on Reader Service Card**

**Variable ratio transmission**

Basic components of this transmission are two disc toroids and three rollers. The toroids face each other and form a full toroidal cavity in which the rollers are mounted on a fixed cage or center section. Rollers have the same diameter as the cavity and can be tilted in the cavity to vary their contact diameter on each of the toroids. Tilting of the rollers against the toroidal surface gives an infinitely variable speed ratio. Mechanical preloading of roller-toroid components

through the toroidal axis permits power transmission by traction from input to output toroid. Ambient temperature tolerance from -65 F to 600 F, with oil inlet temperatures up to 600 F.

*Lycoming Div., Avco Corp., Stratford, Conn.*

**Circle No. 217 on Reader Service Card**

**Aerosol spray lubricant**

Rulon Spray offers a fast easy way to apply a low friction dry film which is chemically inert and thermally stable to over 500 F. Reported to

have coefficient of friction as low as .07. Suitable for belts, gears, bearings, cord, cable, conveyors etc.

*Dixon Corp., Bristol, R. I.*

**Circle No. 218 on Reader Service Card**

**Miniature dc tachometer**

Model SS-779E-1 weighs under 1 1/2 oz, has an overall diameter of 3/4 in. and an armature inertia of 3.5 gm-cm<sup>2</sup>. Other dimensions are to SAE Size 8 motor standards. Output is 3 volts per 1000 rpm; rms value of the ripple is less than 3% of the dc output. Linearity is 1/10 of 1%.



**THE DEPENDABLE  
"LONG SERVICE"  
POWER TAKE-OFF**

**TULSA®**

**INSTALL  
AND FORGET**

It's that simple . . . install and forget the Tulsa Power Take-Off, with full assurance of its complete dependability and long life. Tulsa Power Take-Offs are lighter, stronger, quieter—yet competitively priced. They're always available — for practically any application — through the sales-service facilities of our world-wide dealers and distributors. Ask for a "TULSA" Power Take-Off by name!

**TULSA PRODUCTS DIVISION**

VICKERS INCORPORATED  
Division of Sperry Rand Corporation  
731 E. First Street  
TULSA 20, OKLAHOMA

**Circle No. 58 on Reader Service Card**

## More equipment manufacturers choose Fast's Couplings than any other gear-type coupling



Leaving other claims aside, the thing that counts in couplings is customer confidence—and industrial equipment manufacturers have made Fast's their overwhelming choice. The Fast's line is more diversified, too—in a complete range of sizes and types for shafts, from 1/4" to 32" and larger.

Every Fast's Coupling brings you superb engineering

only the original gear-type coupling can deliver. Smooth-running units that are designed to outlast the machines they connect. Rapid service from experienced field engineers backed by outstanding stock facilities. Write today for full details on couplings to suit your needs to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 911 Scott St., Baltimore 3, Maryland.



### FAST'S COUPLINGS

Engineered Products Sold with Service

## PRODUCTS continued

Construction data shows an aluminum housing, silver commutator, Mylar insulation, stainless steel armature shaft, and fully shielded grease lubricated ball bearings. Single unit cost is \$32.50.

Servo-Tek Products Co., Hawthorne, N. J.

Circle No. 219 on Reader Service Card

## Removable-brush motor

Externally removable brushes give quick easy replacement on the Redmond Type TW Series motors for fractional hp applications. Suitable



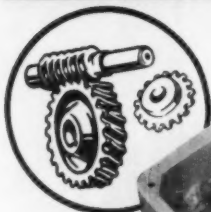
for air conditioners, refrigerator compressors and other appliances where customers do simple maintenance.

Redmond Co., Inc., Owosso, Mich.

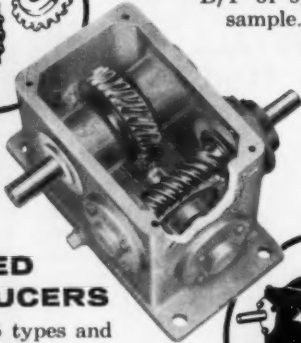
Circle No. 220 on Reader Service Card

From PRECISION GEARS TO ACCURATE SPEED REDUCERS

**Abart** Meets Any Industrial Need



**GEARS**—any type... any material... custom cut to specifications. Send B/P or specs for sample. Request bulletin.



### SPEED REDUCERS

Over 75 types and sizes... fractional to over 400 hp., ratios to 10,000 to 1. Ask for information packed catalog.

Prompt Quotations • Quick Delivery • Write Today!

**ABART GEAR and MACHINE CO.**

4833 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle No. 1 on Reader Service Card



## Industry's NEWEST Production TOOL

**MOLYKOTE® G LUBRICANT**

- ALMOST 100% SAFETY AGAINST GALLING AND SEIZING WITH ALL BEARING METAL COMBINATIONS
- ELIMINATES STICK-SLIP, METAL PICK-UP AND DISTORTION IN PRESS FITTING
- REDUCES WEAR-IN TIME AND DAMAGE IN NEW OR REBUILT MACHINERY
- THE HIGHER THE LOADS, THE GREATER THE MARGIN OF SUPERIORITY OF MOLYKOTE G

Write for your free sample of MOLYKOTE G LUBRICANT today. We will also send you a copy of our new Bulletin 126 which gives complete details. THE ALPHA MOLYKOTE CORPORATION, 65 Harvard Avenue, Stamford, Conn. Phone FReside 8-3724. Plants in Stamford, Conn., Munich, Germany and Strasbourg, France.

FTD-11

THE ALPHA-MOLYKOTE CORP.  
65 Harvard Ave., Stamford, Conn.  
Please send me a free sample of your MOLYKOTE G Lubricant.

NAME \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ ZONE \_\_\_\_\_ STATE \_\_\_\_\_



Circle No. 3 on Reader Service Card

POWER TRANSMISSION DESIGN



# Maxitorq

## 9000 SERIES\*

### ELECTRIC CLUTCHES or BRAKES

Featuring these

#### *Advantages:*

- Compact and Simple Design
- Built to American Standards
- Stationary Coil
- No Slip Rings or Brushes
- Self-Adjusting—Easily Installed
- Drag-free Floating Neutral
- No Stressed Levers or Parts
- Use as Brake or Clutch
- Standard Flange Cups Available

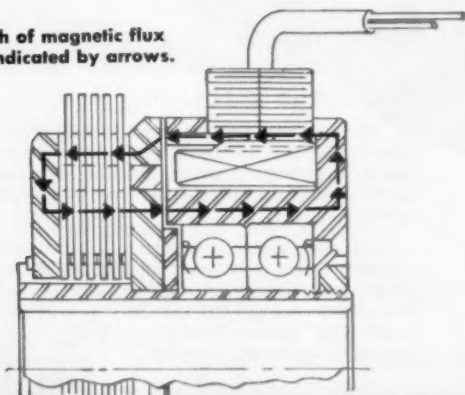


\*Patent applied for.

### OPERATION INDUCED ENTIRELY BY *Magnetic Flux*

The new Maxitorq #9000 Series Electric Clutch is a compact, self-contained unit with operation dependent upon induced magnetic flux. As shown in the drawing below, this new Maxitorq Clutch consists essentially of a sealed magnetic

Path of magnetic flux is indicated by arrows.



coil and housing arrangement actuating multiple discs which also act as the flux path. Because the coil housing, supported on anti-friction bearings, is stationary, troublesome brush and slip ring construction is eliminated. When energized, the entire assembly consisting of pressure plate, inner and outer discs, and buttress plate is locked together by the magnetic force passing through it. When de-energized, Maxitorq separator springs instantly separate the discs creating air gaps which help to break up residual magnetism. Compactness, fast response, and flexibility of control make the #9000 Series clutch or brake ideally suited for a wide range of applications.

Write, phone, or wire Dept. PT now for Bulletin 90 describing the most advanced design of electric clutches or brakes available today.

*Let's talk*  
**MAXITORQ**

THE CARLYLE JOHNSON MACHINE CO. • MANCHESTER, CONN.

Circle No. 37 on Reader Service Card

## WHAT'S YOUR PROBLEM?

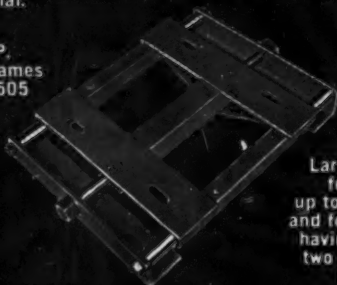
*Is it any of the following?*

- Diminishing output due to a progressive drop in rpm.
- Too much down-time because of the need for frequent adjustment due to belt stretch.
- Excessive maintenance time and expense.
- Poor belt and bearing life.
- A drive in an inaccessible or isolated location.
- A high-ratio short-center drive.

MOUNTING THE MOTOR ON AN "AUTOMATIC" BASE MAY PROVE TO BE A SIMPLE AND ECONOMICAL SOLUTION

Motor mounting position and direction of pulley rotation are immaterial.

Stock Sizes  
1/4 to 125 HP.  
for NEMA frames  
56 through 505  
and 445-U



Larger Sizes  
for motors  
up to 500 HP.  
and for motors  
having one or  
two outboard  
bearings.

**AUTOMATIC MOTOR BASE CO.**  
WINDSOR, N. J.

## FUNK SAVED MONEY FOR THIS COMPANY



On this Dart "Mine Buggy" a compactly-designed Funk transmission provides multiple speed control and doubles as a drop box, thus saving the cost of a 3-stage gear box or a fixed chain drive.

And a Funk Revers-O-Matic Drive, equipped with torque converter, allows the buggy operator to change direction of travel with foot lever only.

Another example of how FUNK MODULAR POWER UNITS can be economically combined — in an unlimited number of arrangements.

Let FUNK solve your power transmission problem.

**FUNK MFG. CO.**

Box 577-G,  
Coffeyville,  
Kansas

## NEW LOW COST STEEL PINTLE CHAIN

Locke "600" Series Steel Pintle Chain is designed for industrial and agricultural applications where cost, adverse operating conditions, low maintenance requirements or use with cast sprockets are governing factors.

The new chain is produced to exceptionally close dimensions and pitch uniformity from high tensile, heat treated steel. A number of attachment links are available for use in conveyor applications.

Low costs result from automatic forming and assembly methods. If your application has cost limitations which prohibit use of roller or malleable pintle chain, write now for information on Locke "600" Series Steel Pintle Chain — available on request in Catalog 60.



**LOCKE STEEL CHAIN COMPANY**

1245 SABINE STREET, HUNTINGTON, INDIANA

## LITERATURE on drives and components

To get free copies of the following literature, use the Reader Service Cards bound into this issue.

### PARALLEL SHAFT REDUCERS

... Book 2719 has 36-pages on 57 sizes, including 23 new sizes. Single, double and triple reduction units up to 2,800 hp at high or low output speeds and ratios to 292:1. Thermal and mechanical hp rating tables for each input and output speed, load classes for 250 driven machines. Overhung loads, extended shafts and out-board bearings, dimensions and actual ratios included in additional tables. *Link-Belt Co.*, Chicago, Ill.

Circle No. 300 on Reader Service Card

### SOLID LUBRICANTS

... are discussed in a 24-page Bulletin 124. Describes the advantages of molybdenum disulfide lubricating powder, grease, resin-bonded coatings and a variety of other forms. Also highlights research facilities and lists company literature. *The Alpha-Molykote Corp.*, Stamford, Conn.

Circle No. 301 on Reader Service Card

### MOTOR REPLACEMENT GUIDE

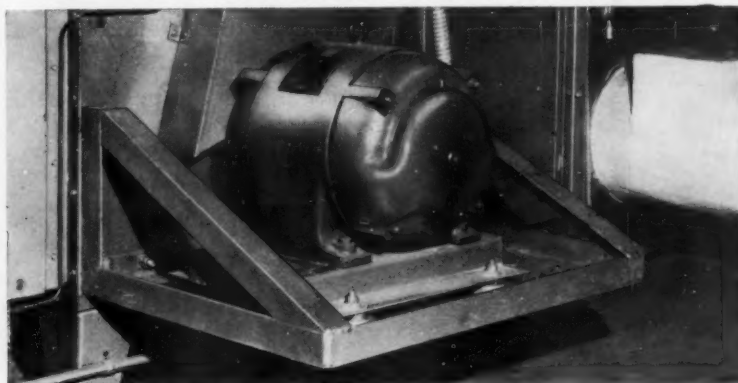
... lists 1428 fractional hp models sold during the last 15 years with the replacement model for each. Describes modifications needed, charts stocking plans for distributors giving the percent of motors presently in use which can be replaced by one of five models. *General Electric Co.*, Schenectady, N. Y.

Circle No. 302 on Reader Service Card

### FLEXIBLE SHAFT ASSEMBLIES

... Catalog No. 6094 illustrates light duty flexible shafts and flexible shaft couplings. Details many standard types and sizes ready for installation as well as component parts such as end fittings, core sizes, casings etc. needed for special assemblies. Outlines design techniques for applying flexible shafts. *Kupfrian Mfg. Corp.*, Binghamton, N. Y.

Circle No. 303 on Reader Service Card



## year 'round solid comfort WITH BROOK MOTORS

Thousands of employees can work in air conditioned solid comfort in hundreds of offices, plants and institutions thanks to the quiet, economical, unfailing performance of Brook a.c. Motors—the motors you can install and forget—the better motors that actually cost less. All standard enclosures—1 to 600 H.P. The 30 H.P. BROOK open drip proof motor shown is one of many driving air conditioning equipment in the new State Office Bldg., Richmond, Va. Send for literature and name of your dealer.



*"World's Most Respected Motor"*

**BROOK MOTOR CORPORATION**

3302-04 W. PETERSON AVE., CHICAGO 45, ILL.

IN CANADA: BROOK ELECTRIC MOTORS OF CANADA, LTD.  
280 UNIVERSITY AVE., TORONTO, ONTARIO

Warehouses, Factory Representatives, Distributors in Principal Cities.

Circle No. 72 on Reader Service Card

NOVEMBER, 1960



Troublesome maintenance and lubricating problems are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

Like a thief in the night an inadequate coupling causes wear and damage to your machines—resulting in high maintenance costs and costly shut-downs.

**NO MAINTENANCE**

**NO LUBRICATION**

**NO WEARING PARTS**

**NO BACKLASH**

**UNDER LOAD and MISALIGNMENT  
only THOMAS FLEXIBLE COUPLINGS  
offer all these advantages:**

- ▶ Freedom from Backlash
- ▶ Torsional Rigidity
- ▶ Free End Float
- ▶ Smooth Continuous Drive with Constant Rotational Velocity
- ▶ Visual Inspection While in Operation
- ▶ Original Balance for Life
- ▶ Unaffected by High or Low Temperatures
- ▶ No Lubrication
- ▶ No Wearing Parts
- ▶ No Maintenance

Write for our New  
Engineering Catalog 60

**THOMAS FLEXIBLE  
COUPLING CO.**  
WARREN, PENNSYLVANIA, U.S.A.

Circle No. 55 on Reader Service Card

*Specify...*

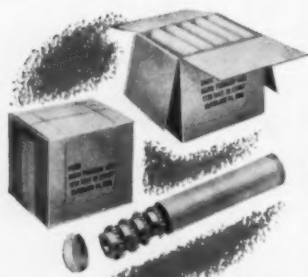


## PUMP GEARS by MICRO for Uniform Accuracy that costs less!

### MICRO PUMP GEARS MEET THESE STANDARDS

- Gear types . . . . . Helical or spur, shaped or shaved, to 5 diametral pitch
- Overall width . . . . . Tolerance .0005" if required
- Outside diameter . . . . . Tolerance .001" if required
- Pitch diameter . . . . . Runout held .003" maximum total indicator reading
- Tooth thickness . . . . . Held to .003"
- Finish . . . . . Ground surfaces 20 Micro-inch or better

All gears are manufactured to your detailed specifications



### Micro Packaging Stops Gear Damage

In transit or in storage this unique packaging system prevents pump gear damage and provides faster, easier handling.

Hydraulic pump gears demand exacting accuracy and they must be uniform in size and surface finish to prevent leakage and reduce wear.

MICRO has turned out thousands of these special gears and has developed methods for hitting tight tolerances right on the head every time! Precision gear cutting machines plus modern testing and gaging equipment play an essential part . . . but, equally important is the special tooling developed by MICRO especially for pump gear production. This special tooling gives you outstanding accuracy and uniformity at a cost you might expect to pay for standard quality gears.

Whether your pump gear needs are 100 — or several thousand — send for a quotation and see for yourself how MICRO can solve your pump "Gearaches" and save money, too!

### SEND FOR NEW BROCHURE

Get the details on MICRO's machines and engineering services. It's free . . . write today!



**MICRO**

PRECISION GEAR & MACHINE CORP.

*designers and manufacturers  
of fine and medium  
pitch gears*

1733 EAST 30th STREET • CLEVELAND 14, OHIO  
TELEPHONE: CHINny 7-6678

Circle No. 44 on Reader Service Card



LITERATURE continued

**MECHANICAL SHAFT SEALS**

... two designs in general purpose mechanical shaft seals, Types KFA and KFB, are described and illustrated in an 8-page folder. Type KFA is for use where housing bore is a limiting factor; Type KFB is used where axial length must be kept to a minimum. Folder shows cutaway views, includes recommended seal materials and minimum mounting dimensions. *Rotary Seal Div., Muskegon Piston Ring Co., Sparta, Mich.*

Circle No. 304 on Reader Service Card

**SHAFTMOUNTED REDUCERS**

Brochure No. F-2003 features the Shaftmount Synchro gear. Twelve special features are described on cutaway illustrations. Includes service classification, hp rating and frame size selection tables as well as dimension drawings and tables, motor and V-belt positions, tie rod positions, nominal and exact gear ratios and data on the optional nonreverse backstop and optional overload release. *U. S. Electrical Motors, Inc., Los Angeles, Calif.*

Circle No. 305 on Reader Service Card

**CLUTCHES AND CONVERTERS**

... revised edition of the 1957 Engineer's Manual brings up to date all specifications and installation drawing and includes much new information. Gives details of semi-centrifugal Type A3 clutches, more detailed torque converter specifications with performance curves and a run down on the new Type A5 and 13E2 clutches. Eighty-eight pages. *Borg & Beck Div. of Borg-Warner Corp., Chicago, Ill.*

Circle No. 306 on Reader Service Card

**ENDLESS WOVEN BELTS** ... two illustrated brochures deal with the Tilton S5 and the Tilton Super Speed. Both types of belts are used for light power transmission and the S5 is also used in conveyor systems. *Arthur S. Brown Mfg. Co., Tilton, N. H.*

Circle No. 307 on Reader Service Card

**MOTOR GLOSSARY** ... Issue No. 5 of company news pamphlet contains a list of terms used in dealing with fractional hp motors. *Bodine Electric Co., Chicago, Ill.*

Circle No. 308 on Reader Service Card

NOVEMBER, 1960

**Browning MVP**  
**MULTIPLE GROOVE**  
**VARIABLE SPEED DRIVES ...**



**WIDE APPLICATION**  
**at LOW COST**



For reliable and convenient speed variations in drives up to 125 hp, investigate Browning's new MVP line. Consider these many advantages:

- ★ 360° adjustment
- ★ patented locking ring assembly—will not work loose
- ★ concentric grooves — all MVP sheaves are finish-grooved after assembly, providing excellent concentricity and uniform pitch diameters, insuring a true running sheave
- ★ permanently balanced. Flanges do not rotate in adjustment
- ★ easy to adjust—simply unlock two locking screws, turn the locking ring, relock
- ★ ground barrels for precision fit
- ★ precision bored center flanges for close fit, no chatter
- ★ adjusting rings of *unbreakable malleable*
- ★ infinite speed adjustment
- ★ same split taper bushing that is used in the entire Browning line; also fixed bore types

Your Browning Distributor can give you complete details, and new catalog MVP-101. Or write **Browning Manufacturing Company, Maysville, Kentucky.**

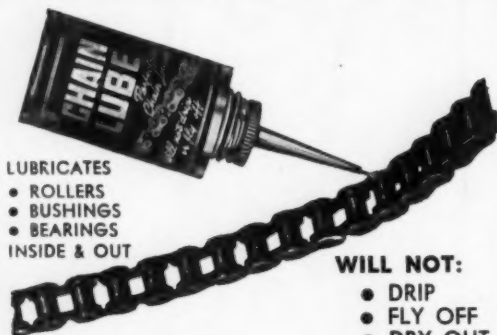
**Browning**  
**POWER TRANSMISSION EQUIPMENT**



FOR PROMPT DEPENDABLE SERVICE CONSULT YOUR BROWNING DISTRIBUTOR  
Circle No. 70 on Reader Service Card

# "CHAIN LUBE"

GOES ON LIKE OIL—STAYS LIKE GREASE



LUBRICATES  
• ROLLERS  
• BUSHINGS  
• BEARINGS  
INSIDE & OUT

WILL NOT:

- DRIP
- FLY OFF
- DRY OUT

IT'S WATERPROOF. THE PERFECT LUBRICANT FOR ALL CHAIN SIZES. ASSURES LONG, TROUBLE-FREE PERFORMANCE—LOWER MAINTENANCE COSTS. COMBATS RUST AND MOISTURE.

## THE McGLAUGHLIN OIL CO.

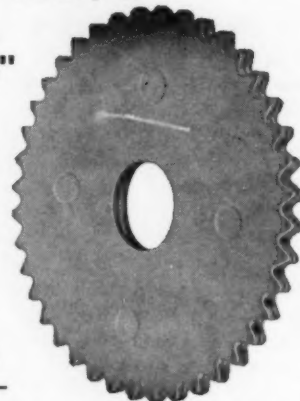
3750 E. Livingston Ave.

Columbus 13, Ohio

FREE SAMPLE CAN SENT WHEN REQUESTED ON COMPANY STATIONERY

Standard, from stock, or Custom-Made to Your "Specs" at Low Cost.

## DIE-CUT ROLLER CHAIN Sprockets



76 Standard Sizes, for A.S.A. No's 35, 40 and 41 chains, in stock for immediate delivery.

Also hub types, special holes, ring types and others including sprockets to your own "specs" can be furnished quickly in small lots or production runs.

Dayton Rogers' short run stamping "know-how", the result of 35 years experience, keeps costs down.

Save with die-cut sprockets made by the Dayton Rogers method.

Write for complete details and representative costs or submit requirements for quotation.

## DAYTON ROGERS

*Manufacturing Company*

Minneapolis 72, Minnesota

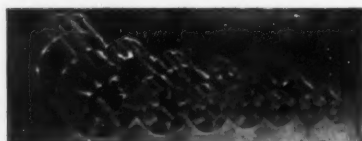
## Couplings for Power Transmission

### Gear-Grip ...

The most revolutionary Flexible Coupling Design Development in a century!

- Now available for subfractional, fractional and integral H. P.
- Ability of rubber Flex-Elements to float between captive end fittings distributing load similar to universal joint action.
- Load Ranges—1/12 H.P. through 30 H.P.
- Shaft Sizes—1/8 through 1 1/2.
- Specified exact length to design requirements per series.
- Prevention of end thrust among many other design advancements.\*

**Dyna-Line** The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



5R 4R 3R 2R 1R 0R 00R

- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Load ranges—1/15 to 1 1/2 H.P.
- Shaft sizes—3/16" to 3/4".
- Lowest O.D. for highest torque capacity.

Write for Catalogs and Technical Bulletins.

## GUARDIAN PRODUCTS CORP.

Circle No. 33 on Reader Service Card

DEPT. PT-1140  
1215 E. SECOND ST.  
MICHIGAN CITY, IND.

## ROTO-GUARD

MOTION INDICATOR

### SHAFT MOTION INDICATOR

PROTECTS MACHINERY BY INDICATING STOPPAGE DUE TO OVERLOADING OR MALFUNCTION

**A and B:** On end return idlers, warn if conveyor should break, slow or stop.  
**C:** On boot pulley, signals slowdown, stoppage, slippage due to overload, boot pulley out of adjustment. Helps prevent fires.

**D:** On screw conveyor, warns of slowdown due to overloading. Prevents damage.

**E:** On rotary feeder, warns of slowdown; prevents plugging damage.

Roto-Guards can be wired into interlock system; stoppage of one component automatically stops others; prevents damage.

Write for Bulletin RG-21 or call VALLEY 2-6952

### THE BIN-DICATOR CO.

13946-E3 Kercheval • Detroit 15, Mich.  
We Sell Direct • Phone Orders Collect

## ADVERTISERS INDEX

Abart Gear & Machine Co. ....	66
Airborne Accessories Corp. ....	15
Alpha-Molykote Corp. ....	66
American Pulley Co. Div. of Van Norman Industries ....	61
American Stock Gear Div. Perfection Gear Co. ....	73
Artus Corp. ....	64
Automatic Motor Base Co. ....	68
Bead Chain Mfg. Co. ....	74
Bin-Dicator Co. ....	72
Charles Bond Co. ....	10
Boston Gear Works ....	53
Boston Woven Hose & Rubber Div. American Bilrite Rubber Co. ....	11
Brewer Machine & Gear Co. ....	2
Brook Motor Corp. ....	69
Browning Mfg. Co. ....	71
Chain Belt Co. ....	13
Cincinnati Gear Co. ....	16
Cone-Drive Gears Div. Michigan Tool Co. ....	Cover III
Crown Gear ....	64
Cullman Wheel Co. ....	17
Dalton Gear Co. ....	54
Dayton Rogers Mfg. Co. ....	72
Diamond Chain Co. ....	57
The duMont Corp. ....	60
Durkee-Atwood Co. ....	5
Eaton Mfg. Co. Cleveland Worm & Gear Div. ....	63
Fawick Airflex Div. Fawick Corp. ....	47
Formsprag Co. ....	50 & 51
Funk Mfg. Co. ....	68
Garlock, Inc. ....	52
Gates Rubber Co. ....	18
Gear Specialties, Inc. ....	60
General Electric Co. ....	48, 49
Globe Gear Co. ....	8
Guardian Products Corp. ....	72
Horsburgh & Scott Co. ....	58
Industrial Clutch Corp. ....	49
Carlyle Johnson Machine Co. ....	67
Koppers Co., Inc. ....	14, 66
Locke Steel Chain Co. ....	68
Lovejoy Flexible Coupling Co. ....	60
Maurey Mfg. Corp. ....	1
The McGlaughlin Oil Co. ....	72
Micro Precision Gear & Machine Corp. ....	70
Morse Chain Co. ....	9
Ohio Gear Co. ....	12
Oil-Rite Corp. ....	64
Precision Tool Mfg. Co. ....	64
Raybestos-Manhattan, Inc. Manhattan Rubber Div. ....	3
Rockford Clutch Div. Borg-Warner ....	62
Rockwell Standard Corp. ....	Cover II
Rollway Bearing Co. ....	45
Stow Mfg. Co. ....	14
Thomas Flexible Coupling Co. ....	69
Triangle Mfg. Co. ....	74
Tulsa Products Div. Vickers Inc. ....	65
Turner Uni-Drive Co. ....	59
United Motors Service Div. General Motors Corp. ....	40
U. S. Electrical Motors, Inc. ....	25
Vickers Inc. ....	8
Westinghouse Electric Corp. ....	6 & 7
Whitmore Mfg. Co. ....	57
T. B. Wood's Sons Co. ....	54, 55

# 956

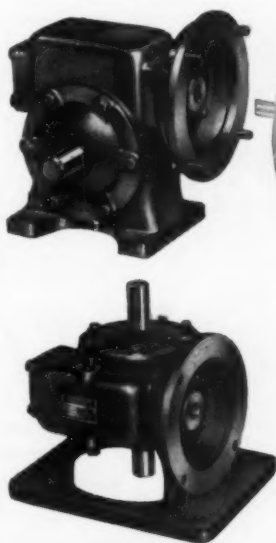
different  
motorized  
speed reducers

available from stock

Yes! 956 different combinations of Perfection Motorized Worm Gear Speed Reducers are available for immediate delivery, *from stock*. Ratios range from 5 to 1 to 60 to 1,

in capacities from 1/6 H.P. to 5 H.P. Perfection "C" Flange Reducers may be ordered complete with motor or without motor, to be used with a motor of your own choice.

Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.



Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.

Licensed under Pat. 2,868,031



**AMERICAN STOCK GEAR DIVISION**  
PERFECTION GEAR COMPANY, HARVEY, ILLINOIS

Circle No. 5 on Reader Service Card

**Circle Reader Service Card from this list for New Product information or Literature**

**NEW PRODUCTS**

*start on page 49*

*circle no.*

- Rotating transmission** .....200  
Airborne Accessories Corp.
- Electro magnetic clutch/hub** ....201  
Cycledynamics Inc.
- Precision spur gears** .....202  
Boston Gear Works
- Variable speed drive** .....203  
Sterling Electric Motors
- Tiny de rate gyro** .....204  
Humphrey, Inc.
- Clutch/brake pot module** .....205  
Autotronics Inc.
- Precision ground shafting** .....206  
Dynamic Gear Co.
- Precision miniature motors** ....207  
Globe Industries, Inc.
- Ball screw and spline assemblies** 208  
Beaver Precision Products, Inc.
- Overload safety device** .....209  
Dalton Gear Co.

- Quick-disconnect flexible shaft** ..210  
Stow Mfg. Co.
- Miniature servo gearhead** .....211  
Exact Engineering and Mfg. Co.
- Rotating electrical connector** ....212  
Ward-Riddle Co.
- Pillow block unit** .....213  
Fafnir Bearing Co.
- Size 11 motor generator** .....214  
Daystrom Inc., Transicoil Div.
- Redesigned gearshift drive** .....215  
Lima Electric Motor Co., Inc.
- Nylon thrust washers** .....216  
Hardware Designers, Inc.
- Variable ratio transmission** .....217  
Lycoming Div., Avco Corp.
- Aerosol spray lubricant** .....218  
Dixon Corp.
- Miniature dc tachometer** .....219  
Servo-Tek Products Co.
- Removable brush motor** .....220  
Redmond Co., Inc.

**LITERATURE**

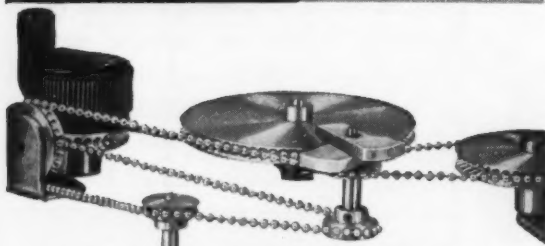
*start on page 69*

*circle no.*

- Parallel shaft reducers** .....300  
Link-Belt Co.
- Solid lubricants** .....301  
The Alpha-Molykote Corp.
- Motor replacement guide** .....302  
General Electric Co.
- Flexible shaft assemblies** .....303  
Kupfrian Mfg. Corp.
- Mechanical shaft seals** .....304  
Rotary Seal Div.,  
Muskegon Piston Ring Co.
- Shaftmounted reducers** .....305  
U. S. Electrical Motors
- Clutches and converters** .....306  
Borg & Beck Div.,  
Borg-Warner Corp.
- Endless woven belts** .....307  
Arthur S. Brown Mfg. Co.
- Motor glossary** .....308  
Bodine Electric Co.

**FOR POSITIVE,  
LOW-COST  
SPROCKET  
DRIVES...**

TRY  
GENUINE  
**B<sup>®</sup> BEAD  
CHAIN**



Now successfully employed in radio and TV tuners, recorders, air conditioners, timing devices, etc. Designed for economical, positive gear trains or drives free of slippage and backlash.

**VERSATILE BEAD CHAIN**

has many other advantageous applications such as:

- part retainers
- remote control devices
- fan or ventilator pulls
- revolving displays
- and many others

WRITE TODAY FOR CATALOG AND SPECIFICATION SHEETS

**THE B<sup>®</sup> BEAD CHAIN MFG. CO.**

Circle No. 8 on Reader Service Card

**TRIANGLE**

**SELF-ALIGNING  
SLEEVE TYPE  
BEARINGS**



Routine or unusual — let us help with your bearing or bearing mounting problems. 20 years' experience furnishing new ideas and quality bearings at low cost to leading mechanical equipment manufacturers.



*Creative design  
and engineering...*

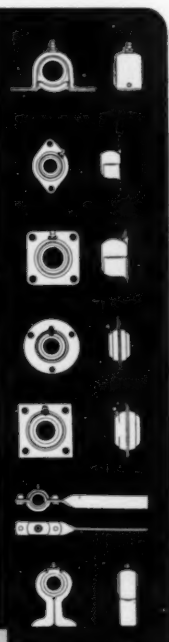
making our products better today . . . so yours may be better tomorrow.

**TRIANGLE  
MANUFACTURING COMPANY**

734 DIVISION ST. • OSHKOSH, WISCONSIN

Circle No. 56 on Reader Service Card

**POWER TRANSMISSION DESIGN**



WRITE FOR  
DESCRIPTIVE  
LITERATURE



# Facts At Your Fingertips

If you want details about products described or advertised in this issue, circle the number on the card that corresponds with the number under each advertisement or product description.

## POWER TRANSMISSION DESIGN

November, 1960.

Circle item numbers for additional information about products described and advertised in this issue.

### ADVERTISEMENTS

1	13	25	37	49	61	73	85	97	107	121	133	145
2	14	26	38	50	62	74	86	98	110	122	134	146
3	15	27	39	51	63	75	87	99	111	123	135	147
4	16	28	40	52	64	76	88	100	112	124	136	148
5	17	29	41	53	65	77	89	101	113	125	137	149
6	18	30	42	54	66	78	90	102	114	126	138	150
7	19	31	43	55	67	79	91	103	115	127	139	151
8	20	32	44	56	68	80	92	104	116	128	140	152
9	21	33	45	57	69	81	93	105	117	129	141	153
10	22	34	46	58	70	82	94	106	118	130	142	154
11	23	35	47	59	71	83	95	107	119	131	143	155
12	24	36	48	60	72	84	96	108	120	132	144	156

Card Invalid Without Company Name — Type or Print

NAME \_\_\_\_\_  
 TITLE \_\_\_\_\_  
 COMPANY \_\_\_\_\_  
 PRODUCT MFG. \_\_\_\_\_  
 ADDRESS \_\_\_\_\_  
 CITY \_\_\_\_\_ ZONE \_\_\_\_\_  
 STATE \_\_\_\_\_

Do not use after Feb. 15, 1961

### NEW PRODUCTS

200	206	212	218	224	230	236	242	248	254	260	266
201	207	213	219	225	231	237	243	249	255	261	267
202	208	214	220	226	232	238	244	250	256	262	268
203	209	215	221	227	233	239	245	251	257	263	269
204	210	216	222	228	234	240	246	252	258	264	270
205	211	217	223	229	235	241	247	253	259	265	271

### FREE LITERATURE

300	306	312	318	324	330	336	342	348
301	307	313	319	325	331	337	343	349
302	308	314	320	326	332	338	344	350
303	309	315	321	327	333	339	345	351
304	310	316	322	328	334	340	346	352
305	311	317	323	329	335	341	347	353

November, 1960.

Circle item numbers for additional information about products described and advertised in this issue.

### ADVERTISEMENTS

1	13	25	37	49	61	73	85	97	109	121	133	145
2	14	26	38	50	62	74	86	98	110	122	134	146
3	15	27	39	51	63	75	87	99	111	123	135	147
4	16	28	40	52	64	76	88	100	112	124	136	148
5	17	29	41	53	65	77	89	101	113	125	137	149
6	18	30	42	54	66	78	90	102	114	126	138	150
7	19	31	43	55	67	79	91	103	115	127	139	151
8	20	32	44	56	68	80	92	104	116	128	140	152
9	21	33	45	57	69	81	93	105	117	129	141	153
10	22	34	46	58	70	82	94	106	118	130	142	154
11	23	35	47	59	71	83	95	107	119	131	143	155
12	24	36	48	60	72	84	96	108	120	132	144	156

Card Invalid Without Company Name — Type or Print

NAME \_\_\_\_\_  
 TITLE \_\_\_\_\_  
 COMPANY \_\_\_\_\_  
 PRODUCT MFG. \_\_\_\_\_  
 ADDRESS \_\_\_\_\_  
 CITY \_\_\_\_\_ ZONE \_\_\_\_\_  
 STATE \_\_\_\_\_

Do not use after Feb. 15, 1961

### NEW PRODUCTS

200	206	212	218	224	230	236	242	248	254	260	266
201	207	213	219	225	231	237	243	249	255	261	267
202	208	214	220	226	232	238	244	250	256	262	268
203	209	215	221	227	233	239	245	251	257	263	269
204	210	216	222	228	234	240	246	252	258	264	270
205	211	217	223	229	235	241	247	253	259	265	271

### FREE LITERATURE

300	306	312	318	324	330	336	342	348
301	307	313	319	325	331	337	343	349
302	308	314	320	326	332	338	344	350
303	309	315	321	327	333	339	345	351
304	310	316	322	328	334	340	346	352
305	311	317	323	329	335	341	347	353

NO POSTAGE STAMP NECESSARY IF MAILED IN UNITED STATES

**BUSINESS REPLY MAIL**

POSTAGE WILL BE PAID BY: *Reader Service Department*

**POWER TRANSMISSION DESIGN**

**812 Huron Road  
Cleveland 15, Ohio**

FIRST CLASS  
PERMIT No. 8066  
CLEVELAND, OHIO

**Facts at  
your  
fingertips**

The most modern Reader Service Department in the publishing industry, staffed and trained to help readers. Automatic equipment processes your requests and shoots them on for fulfillment within hours after receipt. The materials you want get to you — fast.

NO POSTAGE STAMP NECESSARY IF MAILED IN UNITED STATES

**BUSINESS REPLY MAIL**

POSTAGE WILL BE PAID BY: *Reader Service Department*

**POWER TRANSMISSION DESIGN**

**812 Huron Road  
Cleveland 15, Ohio**

FIRST CLASS  
PERMIT No. 8066  
CLEVELAND, OHIO

These cards are your tickets to this prompt service. Use them to secure details about any item in this issue that has a key number. For instance:

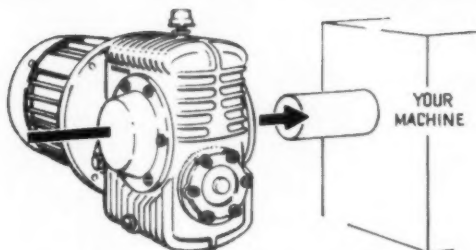
**ADVERTISEMENTS** — a showcase of the latest in components, equipment & techniques.

**NEW PRODUCTS** — brief descriptions of significant new products and materials.

**PRODUCT APPLICATIONS** — brief reports on successful applications of recently developed products and materials.

**NEW LITERATURE** — offerings of new catalogs, data books, price lists, and other valuable reference material.

# CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



**Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .**

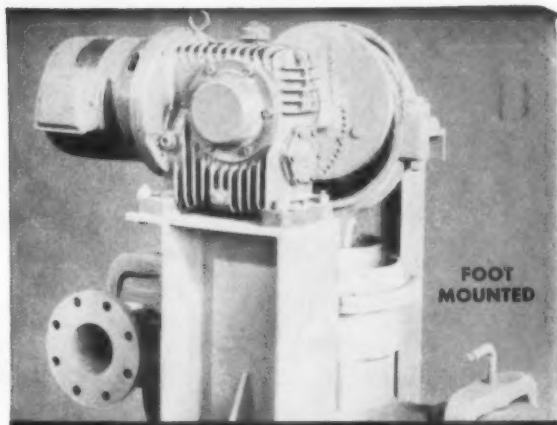
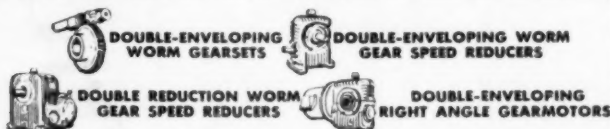
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from  $\frac{1}{4}$  to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

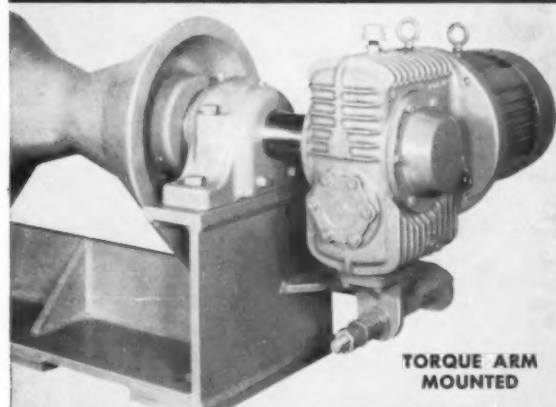
Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

## CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

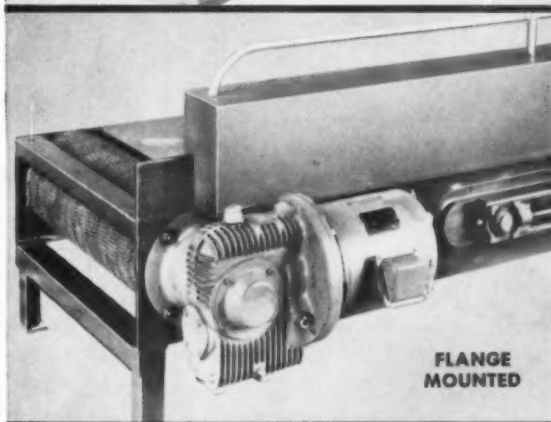
7171 E. McNichols Road Detroit 12, Michigan Telephone: TWInbrook 1-3111



FOOT  
MOUNTED



TORQUE ARM  
MOUNTED

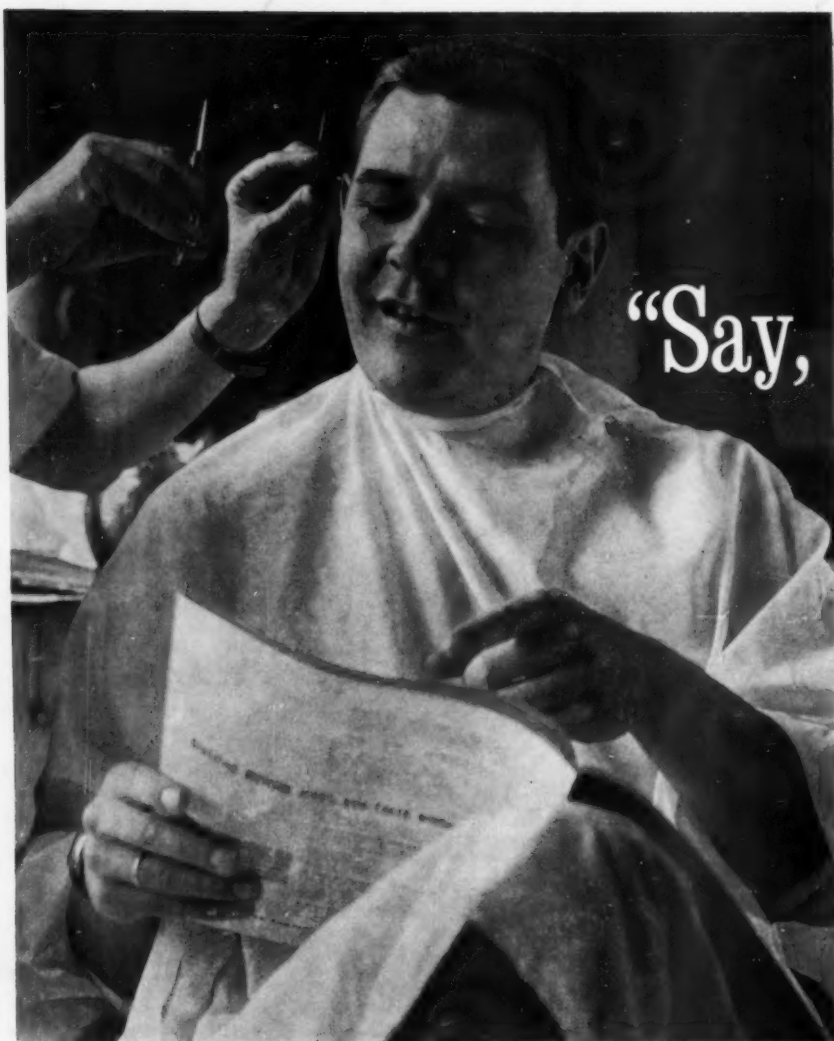


FLANGE  
MOUNTED



TORQUE  
ARM  
MOUNTED

Circle No. 16 on Reader Service Card



“Say, I can  
sure  
use  
this  
idea”

**IDEAS** . . . that's what **POWER TRANSMISSION DESIGN** is here for. It is written by power transmission specialists for power transmission specialists: men like you. **POWER TRANSMISSION DESIGN** is edited to solve both original equipment and in-plant design and maintenance problems.

To build this hard-working editorial package, staff members travel regularly. They cross the country, talking with the people and studying the developments that make news in the power transmission field.

You get the benefits. Between these covers you'll find ideas you can use. Program ideas: they show you what other fellows are doing that you may want to copy. Product ideas: they show you the latest in equipment available to you.

Why not check the contents page right now. There are bound to be several articles you'll want to read. And, for full details on any item described or advertised in this issue, just use the handy Reader Service Cards.

## **POWER TRANSMISSION DESIGN**

Published by Power Publishing Company, Inc., a subsidiary of The Industrial Publishing Corporation

812 HURON ROAD • CLEVELAND 15, OHIO • SUPERIOR 1-9620  
OFFICES: NEW YORK • CHICAGO • LOS ANGELES • LONDON



*Franchise  
Circulation  
gets magazines  
to the men  
who buy*



*Distilled  
Writing gets  
magazines  
read*



